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Evaluation of the Technological Competences Through Dissemination of Knowledge in Technological Incubators with Faph

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Abstract: Unlike the industrial economy that valued vertical integration, the knowledge economy stimulates and values the formation of interorganizational alliances and business arrangements built in networks. Competitiveness shifts from a one-way, individual and endogenous process within firms to an open, multidirectional, collaborative and networked process. In this context, the objective of this study is to evaluate the technological competences (using the SECI model of knowledge conversion) present in technological incubators, through fuzzy multi-criteria methods. A hybrid mathematical methodology will be used with the integration of the Fuzzy Delphi (FDelphi) and Fuzzy Analytic Hierarchy Process (FAHP) methods. The FDelphi will serve to raise and validate the critical factors (criteria/subcriteria) present to evaluate technological competencies in technological incubators. The FAHP method will be applied to calculate the relative weights of the selected criteria/subcriteria that affect the problem in question. Regarding the results, the following criteria were obtained: C_4 (Socialization-38%), that is, the way in which the employees of an incubator share the knowledge, the second one that stood out the most was C_1 (External acquisition of knowledge-28%) sources from which employees acquire tacit and/or explicit knowledge of the incubator's external environment. This proposal is expected to improve the competitiveness of technology incubators by assessing technological skills and disseminating knowledge.
Keywords: incubators, knowledge, technological skills, multicriteria methods, technological competences

1. Introduction

It is widely perceived that current society is in transformation (in advanced degree) to a society of knowledge and technology. The increasing importance of knowledge in society requires a change in thinking about innovation in business organizations, be it technological innovation, product or service innovation, strategic or organizational innovation. So, any organization that dynamically deals with a changing environment must not only process information efficiently but also create information and knowledge.

From the mid-1990s onwards, attention was focused on the development of optimization models as a result of endogenous technological changes[1,4]. The most important feature of endogenous technology change models is that, as experience in new technologies accumulates, their cost of use tends to decline. Thus, what is called 'technological learning' is a classic example of increasing returns[2,3].

Recently, interest in the spatial characteristics of technological learning has increased substantially and includes research under a number of thematic (eg industrial districts, innovative media, local or regional innovation systems, learning regions, clusters, technological incubators regional and global production, and the creative field).

The technological learning[5,6] in companies is related to the processes that promote the acquisition of knowledge. As well as with the extension of knowledge acquired by individuals to the organizational level. That is, technological learning is related to the processes by which individual learning becomes organizational learning, which allows the construction and accumulation of skills necessary for the development of innovations.

In this context, technological skills are the necessary resources to create and manage improvements in investments, processes and organization of production, products, services and equipment. These resources are accumulated and incorporated into individuals (experience and skills, tacit knowledge) and organizational systems[7,8].

Technological resources[9,10] are understood as the ability to use technological knowledge efficiently to assimilate, use, adapt and change existing technologies, as well as the capacity to create new technologies, research and development

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(R&D), develop new products and processes.

For this research the chosen study object was technological incubators, these often located between universities and industry, mediating the process of innovation. In this way, the following research question emerges: how to evaluate technological competencies through multicriteria decision making (MCDM)[11], considering the learning processes in technological incubators?

The relevance and justification of the theme are clear. In the knowledge economy[12] the effectiveness of decentralization and production specialization depends on a combination of strategic alliances and cooperation projects between companies and operates under two main configurations: producer-controlled production chains (in sectors such as automobiles, computers, aircraft, machinery and electrical equipment), and productive chains controlled by buyers (in sectors such as clothing, footwear, toys and household appliances). Several reasons may justify this study, but the main ones are:

When it comes to levels of analysis, knowledge flows can be measured at three levels: macro, meso and micro. The macro deals with international knowledge flows and managerial topics the micro deals with the contribution of knowledge acquisition capacities and their transference and the meso captures the pattern of the interindustry knowledge flows.

However, the knowledge flow at incubator level receives relatively little attention compared to other levels.

Knowledge flows are also important determinants for superior incubator performance[13]. The resource-based theory of competitive advantages suggests that knowledge creates performance-enhancing opportunities for companies able to effectively identify, access, use, and disseminate these resources[14]. Precisely these attributes and knowledge confer superior performance in incubators.

Combinations of resources that generate internal changes such as external knowledge resources, and the links between them, have been described as systems of industrial knowledge. The knowledge systems are different from the production systems, since it refers to networks of autonomous producers. But interdependent and include the projects of products, materials, machines, labor inputs and the transaction links involved in the production of goods.

Therefore, the use of knowledge has been seen as a significant factor in the achievement of competitive advantages by companies. Competitive advantages are developed through the ability of companies to identify, pool and use knowledge in such a way as to obtain maximum value from it. In relation to incubators, this study can contribute to its competitiveness and to the economic and social development of the regions.

Based on the question of research formulated, considering the justifications, it was established the objective of the research as being to evaluate the conversion of knowledge in technological incubators through fuzzy multi-criteria methods in their learning process. The mechanisms and structures of creation, dissemination and sharing of knowledge will be verified, the criteria and sub-criteria will be evaluated to evaluate the technologies competences in technological incubators through the learning process and validated the criteria and sub-criteria with multi-criteria fuzzy methods in an application in a set of incubators in the states of Paraná and Rio Grande Sul, Brazil.

2. Technological competences, conversion of knowledge and incubators of enterprises

The term technological learning is generally understood in two senses[15]. The first refers to the trajectory along which the accumulation of technological competences follows. The trajectory can vary over time: technological skills can be accumulated in different directions and speeds. The second sense refers to the various processes by which knowledge is acquired by individuals and converted to the organizational level. That is, the processes by which individual learning becomes organizational learning.

Taking Bell and Pavitt's vision[7-8] one can define technological competence as the necessary resources to generate and manage improvements in processes and organization of production, products, equipment and investments. And, these resources are accumulated and aggregated into individuals (skills, knowledge) and organizational systems. In reality, technological competence[16] refers to the firm's abilities to implement internal improvements in different technological functions, such as products, equipment, among others.

From the assumption that knowledge is created by means of the interaction between the tacit and the explicit, it made possible to postulate four different modes of knowledge conversion-SECI-[17-19]. (1) Socialization (conversion from tacit to tacit); (2) Externalization (conversion of the tacit into explicit); (3) Combination (conversion from explicit to explicit) and (4) Internalization (from explicit to tacit). Such interactions are conditioned by the changes between the four different modes of knowledge conversion, which interact in the spiral of such creation.

In the conception[20] the accumulation of technological competences arises from the learning processes. That is, it is the conversion of knowledge[5]:

1. Processes of external acquisition of knowledge-are the processes by which individuals acquire tacit and/or explicit knowledge of the environment external to the company. For example: importing expertise or experts from outside the company, training abroad, attending conferences and relational events, providing scholarships, interactions with suppliers and users; among others.

2. Processes of internal acquisition of knowledge-people acquire knowledge by performing different activities within the company. For example, improvements in existing processes and organization of production, equipment and products. The process can also take place through Research and Development (R&D) activities, laboratories/or systematic experimentation in all operational units and production lines, on-the-job/learning-by operation (learning-doing) activities.

3. Knowledge socialization processes-employees share their tacit knowledge. That is, all formal and informal processes by which tacit knowledge is transmitted from an individual or to a group (e.g. observation, meetings, shared problem solving, and work rotation, basic or advanced internal training, team building, dissemination of leading operators, shared problem solving, among others). Training can also function as a process of knowledge, socialization. For during training programs, individuals of different backgrounds and experience can socialize tacit knowledge with trainees and instructors, and this framework considers different types of training.

4. Process of knowledge codification-tacit knowledge becomes explicit, enabling the dissemination of knowledge in the company. The processes by which tacit knowledge is articulated in explicit concepts, in accessible, organized formats and procedures, and becomes easier to understand. As a consequence, the process facilitates the dissemination of knowledge throughout the company (standardization practices, production procedures, automation systems, external training description, quality system manuals, etc.). The elaboration of training modules by individuals may involve both knowledge-socialization and knowledge-codified processes. Thus, processes (1) and (4) are critical for individual conversion into the organizational learning system.

Based on the literature, the concept of technological competencies in this work is defined as: the resources needed to generate and manage improvements in organizational processes, products/services and, consequently, their performance. At one time, these resources are incorporated into the people and systems of the organization. And in turn technological skills are accumulated through learning. And the learning process used will be the SECI model proposed by [20]. The learning process is defined as the various processes by which knowledge is acquired by individuals and converted to the organizational level.

Consequently, by building technological competencies, organizations are able to undertake innovative activities in products, services, processes and equipment to compete in the global marketplace.

3. Materials and methods

Firstly, it was applied the Fuzzy Delphi (FDelphi), used to raise the critical factors (criteria/sub-criteria) present to evaluate the technological competences. The Fuzzy AHP (FAHP) method was applied to calculate the relative weights of the selected criteria/sub-criteria that affect the technologies competencies and thus, therefore, the organizational performance.

Fuzzy set theory is a viable method for dealing with imprecise and uncertain information in a real world[21]. This theory provides a broader framework than classical set theory, contributing to the ability to reflect the real world. It is more appropriate for subjective judgments and qualitative evaluation in decision-making evaluation processes than other classical methods of evaluation that clearly apply the values[22-26].

A fuzzy number is a set special $F = \{x \in R / \mu_F(x)\}$, where x assumes real values.

$R_1 : -\infty < x < +\infty$ e $\mu_F(x)$ is a continuous mapping of R1 to the closed interval [0,1]. A positive fuzzy triangular number (TFNS) $\tilde{T}$ can be defined as a triple $\tilde{T} = (l, m, u)$, which corresponds to a e function $\mu_T(x)$ defined by Equation 1.

$$\mu(x) = \begin{cases} \frac{x-l}{m-1} & l < x < m \\ \frac{u-x}{u-m} & m < x < u \\ 0 & \text{case reverse} \end{cases} \quad (1)$$

The mathematical modeling used in this paper is the extension analysis of the FAHP for the calculation of criteria weights and sub-criteria for the study objective proposed by [27]. The use of this is due to the fact that the steps of this approach are similar to conventional AHP and relatively easier than the other FAHP approaches. The triangular fuzzy scale used in this work is given in Table 1.

Table 1. Fuzzy scale used in the research

Linguistic Scale	Triangular Fuzzy Scale	Triangular Fuzzy Reciprocal Scale
Equals (JI)	(1,1,1)	(1,1,1)
Same importance (II)	(0.66,1,1.5)	(0.66,1,1.5)
Little important (FRAI)	(1,1.5,2)	(0.5,0.66,1)
Very Important (FORI)	(1.5,2,2.5)	(0.4,0.5,0.66)
Very strongly Important (MFI)	(2,2.5,3)	(0.33,0.4,0.5)
Absolutely Very Important (AMI)	(2.5,3,3.5)	(0.29,0.33,0.4)

AHP is widely used to solve multi-criteria decision problems in real situations. The fuzzy approach is used to compensate for the inaccuracy of conventional AHP in relation to its degree of importance in the judgment of decision makers. For the conventional AHP method the results would only be related to the established criteria and do not consider resource constraints[28]. Consequently, this will lead to less information for decision makers. The FAHP and its extensions are developed to solve problems of selection and justification of alternatives[27]. Although the FAHP requires tiresome calculations, it is able to capture ambiguity in human assessment when complex multi-criteria decision-making problems are considered.

Being $X = \{x_1, x_2,..., x_n\}$ a set of objects, and $U = \{g_1, g_2,..., g_m\}$ the set of goals, according to the method of [27], the analysis can be performed with each object and its respective goal g_1 resulting in m values for each object considering goal. May be, $m_{gi}^1, m_{gi}^2, ..., m_{gi}^m$, $i = 1, 2,..., n$ where every m_{gi}^j ($j = 1, 2,..., m$) are NFTs, representing the performance of the object x_i for each goal u_j. For this work will be used the extension to the FAHP, proposed by [27], that is:

Step 1: The value of the fuzzy extension in relation to the i-th object is defined by Equation 2.

$$s_i = \sum_{j=1}^{m} m_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} m_{gi}^j \right]^{-1} \quad (2)$$

Where $\otimes$ denotes the extended multiplication of two fuzzy numbers, in order to obtain $\Sigma_{j=1}^{m} m_{gi}^j$ to perform the fuzzy addition operation of m extension analysis values for a particular matrix such that Equation 3.

$$\sum_{j=1}^{m} m_{gi} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \quad (3)$$

To get $\left[\Sigma_{i=1}^{n} \Sigma_{j=1}^{m} m_{gi}^j \right]^{-1}$, the fuzzy operation of addition of m_{gi}^j ($j = 1, 2,..., m$) in order to Equation 4:

$$\sum_{t=1}^{n} \sum_{j=1}^{m} m_{gi}^j = \left(\sum_{j=1}^{n} l_j, \sum_{j=1}^{n} m_j, \sum_{j=1}^{n} u_j \right) \quad (4)$$

Then to calculate the inverse of the vector we have Equation 5:

$$\left[\sum_{t=1}^{n} \sum_{j=1}^{m} m_{gi^j} \right]^{-1} = \left(\frac{1}{\sum_{j=1}^{n} u_j}, \frac{1}{\sum_{j=1}^{n} m_j}, \frac{1}{\sum_{j=1}^{n} l_j} \right) \quad (5)$$

Step 2: The degree of possibility for $\bar{m}_2 = (l_2, m, u_2) \geq \bar{m}_1 = (l_1, m_1, u_1)$ is defined by Equation 6:

$$V(\bar{m}_2 \geq \bar{m}_1) = \sup_{y \geq x} \left[\min(\bar{m}_1(x), (\bar{m}_2(y)) \right] \quad (6)$$

And can be expressed by Equation 7.

$$V(\overline{m}_2 \geq \overline{m}_1) = hgt(\overline{m}_2 \cap \geq \overline{m}_1) = \overline{m}_2(d) = \begin{cases} 1 \; se m_2 \geq m_1 \\ 0 \; se l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \text{caso contrário} \end{cases} \quad (7)$$

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i (i = 1, 2, 3,..., k) may be defined by Equation 8.

$$V(M \geq M_1, M_2, ..., M_k) = V[(M \geq M_1)] \; e \; (M \geq M_2) \; e...e \; (M \geq M_k) = \min V(M \geq M_i), i = 1, 2, 3, ..., k \quad (8)$$

Then the Equation 8 assumes the Equation 9:

$$d'(A_1) = \min V(S_i \geq S_k) \quad (9)$$

for k = 1, 2,..., n; $k \neq i$ when the weight of the vector is given by Equation 10.

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n)) \quad (10)$$

where A_i (i = 1, 2,..., n) are n elements.
Step 4: By the normalization of the weights we get the Equation 11:

$$W = (d(A_1), d(A_2), ..., d(A_n)) \quad (11)$$

Where W is a non-fuzzy Vector.
The Equation 11 assumes the form of the Equation 12.

$$d'^{(A_i)} = \min V(S_j \geq S_i) \quad (12)$$

For j = 1, 2,..., n; $j \neq i$.
Then the weight vector (Equation 13) is given by:

$$W' = (d'^{(A_1)}, d'^{(A_2)}, ..., d'^{(A_n)})^T \quad (13)$$

Where A_i (i = 1, 2,..., n) has n elements.
Step 5: Through normalization, the weight vectors are normalized by Equation 14. Where W is a non-fuzzy number.

$$W = (d(A_1), d(A_2), ..., d(A_n))^T$$

Step 6: Step 6: Calculate the global weights[23] for sub-criteria. The global sub-criteria weights are calculated by multiplying the local weight of the sub-criteria with the weight of the criteria to which it belongs. Global weights are denoted by $w_{sub}^i = (w_{i1}, w_{i2}, ..., w_{ini})$, where n_i is the number of sub-criteria with respect to i_n criteria. The present research instrument was elaborated from the literature on creation, dissemination of knowledge and technological competencies.

4. Results

The interviewees were managers (specialists) of technological incubators, located in the South region, specifically in the state of Paraná and Rio Grande do Sul, to the total were consulted six specialists. Sampling was chosen randomly. In order to gather the classifications of the sub-criteria, the linguistic variables and their semantics were explained to the specialists. The FDelphi method was used to "filter" sub-criteria (the initial questionnaire had sixty-four sub-criteria), the final questionnaire (Table 2) consisted of twenty-eight sub-criteria. For this purpose, a "cut-off point" was defined, i.e. a value α, whose values less than or equal to 3.10 were eliminated.

Table 2. Criteria (C) and sub-criteria (Sc) to evaluate technological competences through the SECI model (Final version)

Criteria	Sub-criteria	Description of sub-criteria
External acquisition of knowledge	Sc_1	Interaction with clients, educational institutions and suppliers for the development of projects.
	Sc_2	Management development programs.
	Sc_3	Hiring of experts, companies and external consultants.
	Sc_4	Visits to national and international events (fairs, congresses and seminars).
	Sc_5	Visits of production and technical staff to customers and suppliers.
	Sc_6	Hiring former employees of competing companies.
Internal acquisition of knowledge	Sc_7	Research and Development (R&D) activities.
	Sc_8	Acquisition of knowledge before engaging in new technical activities.
	Sc_9	Through the company's routine operating activities.
	Sc_{10}	Efforts to continually improve the organization.
	Sc_{11}	Use of online training such as e-learning, b-learning.
	Sc_{12}	Adoption of the "learn by doing" philosophy.
	Sc_{13}	Internal training of employees
	Sc_{14}	Search learning.
	Sc15	Capturing and transferring knowledge through specialists.
Knowledge Coding	Sc16	Standardization practices and detailed production procedures.
	Sc17	Coding of engineering projects, with the computerization of the company and acquisition of graphic software.
	Sc18	Description of external and internal training and events.
	Sc19	Operational and management control systems.
	Sc20	Elaboration of administrative procedures (norms, regulations, internal communication and technical instructions).
Knowledge Socialization	Sc21	By direct observation and training in the workplace.
	Sc22	The creation of work groups and empowerment teams.
	Sc23	Use good market practices (benchmarking).
	Sc24	Knowledge replicator formation.
	Sc25	Provide electronic documentation for operational procedures and execution of activities.
	Sc26	Exchanges of information with clients for the development of projects.
	Sc27	Development of prototyping of products/services.
	Sc28	Dynamic combination through e-mail, Internet, Intranet.

The weights of the criteria and sub-criteria were calculated using the comparison fuzzy values using the method of [27]. Table 3 shows the shows the formation of the pair comparisons of the criteria, using the fuzzy numbers. The same was done for the sub-criteria.

Table 3. Formation of the comparisons (fuzzy) of the pairs for the criteria

	C_1	C_2	C_3	C_4
C_1	(1,1,1)	(2,2.5,3)	(2,2.5,3)	(0.33,0.4,0.5)
C_2	(0.33,0.4,0.5)	(1,1,1)	(1.5,2,2.5)	(0.33,0.4,0.5)
C_3	(1.5,2,2.5)	(2.5,0.5,0.67)	(1,1,1)	(0.33,0.4,0.5)
C_4	(2,2.5,3)	(2,2.5,3)	(2,2.5,3)	(1,1,1)

The value of the synthetic fuzzy measure was then calculated. Firstly, it's were performed for the criteria: External acquisition of knowledge (C_1), Internal acquisition of knowledge (C_2), Knowledge Coding (C_3) and Knowledge Socialization (C_4), that is to say:

$$C_1 = \Sigma_{j=1}^{4} C_{g1}^{j} = (1,1,1) \oplus (2,2.5,3) \oplus (2,2.5,3) \oplus (0.33,0.4,0.5) = \Sigma(5.33,6.4,7.5).$$

$$C_2 = \sum_{j=1}^{4} C_{g2}^{j} = (0.33,0.4,0.5) \oplus (1,1,1) \oplus (1.5,2,2.5) \oplus (0.33,0.4,0.5) = \sum (3.16,3.80,4.5)$$

$$C_3 = \sum_{j=1}^{4} C_{g3}^{j} = (1.5,2,2.5) \oplus (2.5,0.5,0.67) \oplus (1,1,1) \oplus (0.33,0.4,0.5) = (5.33,3.9,4.67)$$

$$C_4 = \sum_{j=1}^{4} C_{g4}^{j} = (2,2.5,3) \oplus (2,2.5,3) \oplus (2,2.5,3) \oplus (1,1,1) = (7,8.5,10)$$

Then:

$$\sum_{i=1}^{4}\sum_{j=1}^{4} M_{gi}^{j} = (5.33,6.4,7.5) \oplus (3.16,3.80,4.5) \oplus (5.33,3.9,4.67) \oplus \left(7,8.5,10\right) = (20.82,22.6,26.67)$$

$$\left[\sum_{i=1}^{m}\sum_{j=1}^{m} M_{ij}\right]^{-1} = \left(\frac{1}{20.82},\frac{1}{22.6},\frac{1}{26.67}\right) = (0.037495313, 0.044247788, 0.04803074)$$

Then:

$$C_1 = (5.33,6.4,7.5) \otimes \left(0.037495313, 0.044247788, 0.04803074\right) = \left(0.199850018, 0.283185792, 0.360230550\right)$$

$$C_2 = (3.16,3.80,4.5) \otimes \left(0.037495313, 0.044247788, 0.04803074\right) = \left(0.118485189, 0.168141564, 0.216138330\right)$$

$$C_3 = (5.33,3.9,4.67) \otimes \left(0.037495313, 0.044247788, 0.04803074\right) = \left(0.199850018, 0.172566342, 0.224303556\right)$$

$$C_4 = (7,8.5,10) \otimes \left(0.037495313, 0.044247788, 0.04803074\right) = \left(0.262467191, 0.376106130, 0.480307400\right)$$

The following vectors were obtained for the:

V(S1≥S2) = 0.12	V(S1≥S3) = 0.18	V(S1≥S4) = 1
V(S2≥S1) = 1	V(S2≥S3) = 1	V(S2≥S4) = 1
V(S3≥S1) = 1	V(S3≥S2) = 0.79	V(S3≥S4) = 1
V(S4≥S1) = 0.51	V(S4≥S2) = 0	V(S4≥S3) = 0

The weight vector, shown in Table 4 is calculated as W = (0.28, 0.17, 0.17, 0.38). This means that from the point of view of the specialists, the most important degree (P = 0.38) was attributed to the C_4, that is, the Socialization of knowledge. The lowest degree of importance was for C_2 and C_3 with P = 0.17 for both.

Table 4. Vector criteria weight

Criteria	C_1	C_2	C_3	C_4	Weight
C_1	(1,1,1)	(2,2.5,3)	(2,2.5,3)	(0.33,0.4,0.5)	0.28
C_2	(0.33,0.4,0.5)	(1,1,1)	(1.5,2,2.5)	(0.33,0.4,0.5)	0.17
C_3	(1.5,2,2,.5)	(2.5,0.5,0.67)	(1,1,1)	(0.33,0.4,0.5)	0.17
C_4	(2,2.5,3)	(2,2.5,3)	(2,2.5,3)	(1,1,1)	0.38

The local and global weight for the sub-criteria was calculated similarly to the evaluation fuzzy matrices, as shown in Table 5. The local weight for the sub-criteria is calculated similarly to the fuzzy matrices, as shown previously. Part of the peer-to-peer comparison matrix for sub-criteria is shown in Table 5 where the local weight of each sub-criteria can also be visualized for the criterion "External acquisition of knowledge".

Table 5. Local weights and peer-to-peer comparison matrix of the sub-criterion of "External knowledge acquisition"

	Sc_1	Sc_2	Sc_3	Sc_4	Sc_5	Sc_6	Weight
Sc_1	(1,1,1)	(2,2.5,3)	(2,2.5,3)	(2,2.5,3)	(2,2.5,3)	(2,2.5,3)	0.2836
Sc_2	(0.33,0.4,0.5)	(1,1,1)	(0.4,0.5,0.66)	(0.33,0.4,0.5)	(1.5,2,2.5)	(1.5,2,2,.5)	0.1324
Sc_3	(0.33,0.4,0.5)	(1.5,2,2.5)	(1,1,1)	(0.33,0.4,0.5)	(1.5,2,2.5)	(1.5,2,2.5)	0.1639
Sc_4	(0.33,0.4,0.5)	(2,2.5,3)	(2,2.5,3)	(1,1,1)	(2,2.5,3)	(2,2.5,3)	0.2395
Sc_5	(0.33,0.4,0.5)	(0.4,0.5,0.66)	(0.4,0.5,0.66)	(0.33,0.4,0.5)	(1,1,1)	(1,1.5,2)	0.0903
Sb_6	(0.33,0.4,0.5)	(0.4,0.5,0.66)	(0.4,0.5,0.66)	(0.33,0.4,0.5)	(1,1.5,2)	(1,1,1)	0.0903

Using the weight of the criteria and the local weight of the sub-criteria, one calculates the global weight for the sub-criteria. That is, for its calculation, the local weight of the sub-criteria is multiplied by the weight of the criterion to which it belongs (Table 6).

Table 6. Global and local weight of sub criteria (Sc)

Weight (criteria)	Sub-criteria	Local weight	Local weight (%)	Global weight	Global weight (%)
$C_1 = 0.28$	Sc_1	0.2836	28.4	0.0794	7.94
	Sc_2	0.1324	13.2	0.0371	3.71
	Sc_3	0.1639	16.4	0.0459	4.59
	Sc_4	0.2395	23.9	0.0671	6.71
	Sc_5	0.0903	9.00	0.0253	2.53
	Sc_6	0.0903	9.00	0.0253	2.53
		1.00	100.00	0.28	28.00
$C_2 = 0.17$	Sc_7	0.0994	9.9	0.0169	1.69
	Sc_8	0.1133	11.3	0.0193	1.93
	Sc_9	0.0948	9.5	0.0161	1.61
	Sc_{10}	0.1750	17.5	0.0297	2.97
	Sc_{11}	0.0442	4.4	0.0075	0.75
	Sc_{12}	0.0856	8.60	0.0146	1.46
	Sc_{13}	0.1832	18.3	0.0312	3.12
	Sc_{14}	0.0912	9.1	0.0155	1.55
	Sc_{15}	0.1133	11.3	0.0193	1.93
		1.00	100.00	0,17	17,00
$C_3 = 0.17$	Sc_{16}	0.2500	25.0	0.0425	4.25
	Sc_{17}	0.3000	30.0	0.0510	5.10
	Sc_{18}	0.2000	20.0	0.0340	3.40
	Sc_{19}	0.1500	15.0	0.0255	2.55
	Sb_{20}	0.1000	10.0	0.0170	1.70
		1.00		0.17	17.00
$C_4 = 0.38$	Sc_{21}	0.1561	15.6	0.0593	5.93
	Sc_{22}	0.0764	7.60	0.0290	2.90
	Sc_{23}	0.1561	15.6	0.0593	5.93
	Sc_{24}	0.1790	17.9	0.0680	6.80
	Sc_{25}	0.2020	20.2	0.0767	7.67
	Sc_{26}	0.1103	11.0	0.0419	4.19
	Sc_{27}	0.0600	6.0	0.0228	2.28
	Sc_{28}	0.0600	6.0	0.0228	2.28
		1.00	100.00	0.38	38.00

For example, the overall weight of sub-criteria present in the criteria (C_1) is: $0.28 \otimes (0.2836,0.1324,0.1639,0.2395,0.0903,0.0903) = (0.0794,0,0371,0,0459,0,0671,0,0253,0,0253)$. Regarding the criterion with the highest local weight for C_1, we have Sc_1 (Interaction with clients, educational institutions and suppliers for the development of projects), with a participation of 28.4%, and its importance in the global weight is 7.94 %, that is, the highest among all the criteria.

For example, in the case of universities, in recent years a notable effort has been made by these associations and government institutions to support innovation, since it is vital to the survival of organizations. The universities have unique characteristics that allow them to be characterized as complex organizations[29-31], and pluralist[29-31]. For technology incubators enable the technology transfer process that helps to promote growth through innovation and supports economic development strategies for the development, for example, of small businesses in a region.

5. Discussion and conclusions

Today, organizations can survive global competition if they can innovate permanently. The ability of employees to create new knowledge, both in terms of products/services, in order to maintain their market value is crucial. This emphasis on permanent innovation transforms the workplace into an environment of learning and innovation.

In this way, the learning process assists in the internalization of new knowledge and improves the quality of thinking and behavior of individuals in organizations. Learning is an interactive process of action and reflection. It also involves the acquisition and knowledge necessary to develop the skills, the development of technological knowledge, know the “How” and the “Why” of the processes and understanding of the information.

Thus, this study had the objective of evaluating the technological competences present in technological incubators, by means of multi-criteria fuzzy methods. Fuzzy logic was integrated into Delphi and AHP-FDelphi and FAHP. That is, giving rise to a hybrid mathematical modeling. Since: FDelphi was used to raise and validate the criteria/sub-criteria present to evaluate technological competencies in technological incubators. The FAHP was applied to calculate the relative weights of the selected criteria/sub-criteria that affect the problem in question.

Thus, first, a questionnaire was drawn up based on the literature on technological competencies related to the SECI model of knowledge conversion. After that it was validated (with FDelphi) with specialists, that is, the managers of six technological incubators, located in the state of Paraná and Rio Grande do Sul.

Regarding the results, the following criteria were obtained: C_4 (Socialization-38%), that is, the way in which the employees of an incubator share the knowledge, the second one that stood out the most was C_1 (External acquisition of knowledge-28%) sources from which employees acquire tacit and/or explicit knowledge of the incubator's external environment.

Regarding the sub-criteria, the following were the highlights: Sc_1 (Interaction with clients, educational institutions and suppliers for development of projects-7.94%); Sc_{25} (Provide electronic documentation for operational procedures and execution of activities-7.67%); Sc_{24} (Knowledge replicator formation-6.80%) e; Sc_4 (Visits to national and international events (fairs, congresses and seminars-6.71).

Therefore, this work shows itself as a contribution to the management of the incubators, as these can be considered as propellants of development and support by the companies of a region. They provide assistance to companies in the early stages of development and thereby collaborate to raise business survival rates. Business incubators typically provide office space, administrative support, and advisory services. Thus, good management of these incubators makes them provide a better service to other companies.

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