

Technology parks strategic capacity evaluation structure: a framework proposal for implementation in Latin America

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Abstract

This study's relevance contributes in an unprecedented manner with a proposal to investigate the strategic capacity evaluation structure of Technological Parks in Latin America. This way, the following research question emerged: how to evaluate the strategic capability of the Technological Parks in Latin America? This study's objective is to present a framework proposal for review of the Strategic Capacity of Technological Parks in Latin America. The methodology used in this study is classified, by the objective, as exploratory and the technical procedure used was the literature review. The research approach used was qualitative and quantitative. As a research result, a 4 dimensions ensemble (Infrastructure, Scenarios, Corporate Governance and Strategic Performance) composed of 31 indicators that can corroborate with the TPs in Latin America was identified, after the MACBETH method application with survey data applied to 10 major decision makers of TPs in Latin America. The proposed index can serve as a comparative evaluation between several Latin America TPs. Further research suggestions are larger exploration of the theoretical references cited and field research framework validation in other continents.

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Keywords: Technology parks; Framework; Strategic capacity

Introduction

The world is always changing. According to Organization for Economic Co-operation and Development [OECD] (2012) report, the USA, the world's major economy representing 23% of world economic activities, will move to 18% in 2030. Euro Zone will move from 17% to 12%. China, which produces 17% of world economic activities today, will move to 28% in 2030, becoming the major world economy. The Chinese growth and other emerging countries will be led by more skilled and productive labor. India will also benefit from population growth and its GNP will move from 7% to 11% on world economy representation (OECD, 2012).

Traditional organizations are being demolished, companies integrate and mischaracterize, starting to form networks, chains, conglomerates and strategic alliances, the so-called post-Fordist organizations (Clegg & Hardy, 1999) adapted to the knowledge era, to the unpredictability fast technological and economic transformation conditions (Castells, 1999), like the technological parks [TP] (Atuahene-Gima and Li, 2004; Lindelöf & Löfsten, 2002; Townsend, Soojung-Kim Pang and Weddle, 2009).

This study, from the theoretical survey conducted and from survey data applied to 10 major decision makers of TP in Latin America (Brazil, Mexico, Argentina, Colombia, Venezuela, Chile, Uruguay and Peru), considers as proposal capable to contribute to the Latin America TP effectiveness, a framework composed of the Corporate Governance, Scenarios, Infrastructure, Strategic Performance dimensions, generators of needed strategic capability to the TP effectiveness.

In this sense, the article aims to make a first theoretical proposal of a Latin American TP strategic capacity index. As each

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dimension of this study framework has differentiated importance, it is recommended that the index is weighted and each weight can express the relative importance of each dimension in the final composition proposal.

For dimensions aggregation, it is proposed to use the expert value judgments of the five largest Latin American TP. To transform the qualitative value judgments into quantitative, in a later work, the adoption of MACBETH multi-criteria method is suggested (Bana e Costa and Vansnick, 1995; Bana e Costa & Vansnick, 1995, 1997). The proposed index can serve as a comparative evaluation between Latin Americans TP.

Theoretical approach and proposals

Conceptualizing, TP are innovation environments managed by specialized professionals, whose goal is to increase the wealth and well-being of their community, stimulate the growth of technology-based companies through incubation and spin-offs, and provide other high value added services combined with a physical space and high-quality support services (Anprotec, 2008; Steiner et al., 2015).

Regarding financing, 70% of TP in the world receive some form of government subsidy (NBIA, 2014). In Brazil, this percentage approaches 90% (MCTI, 2013). In Latin America – excluding Brazil – so far, the involvement of the public sector with TP has been relatively scarce. The result is territorially inefficient TP, unable to promote technological development and knowledge, limited in size due to the low initial levels of investment and little interest from the private sector (Gil-Serrate, 2014; Rodríguez-Pose & Hardy, 2014).

Bannister and Higgins (1991) and Harrison (1997) relate to strategic capacity only the acquisition of competitive advantage and appropriateness of strategic planning to business objectives. Harrison and Miller (1999) point out that the strategic capacity is the company's condition to overcome all these challenges through effective dissemination of its strategy. For some strategic capacity, usually tied to some more specific factors such as the relationship with stakeholders (Collis & Rukstad, 2008); learning and organizational knowledge (Wang et al., 2012); the soundness of the strategy through planning and efficient execution (Bannister & Higgins, 1991; Ismail, Poolton, & Sharifi, 2011; Teece, Pisano, & Shuen, 1997); among others.

An improved and systemic study of TP Strategic Capacity, realized with TPs in Latin America, through proxies Corporate Governance, Scenarios, Infrastructure, Strategic Performance (Fig. 1) is required for the challenges highlighted by the necessary harmony between its various actors (stakeholders and shareholders), and also, surveys pointed to a “lack of performance index” appropriate management and evaluation of these institutions (Link & Siegel, 2003; Phan, Siegel, & Wright, 2005; Vedovello, 1997, p 107; Yim, Seong, Lee, Park, & Hong, 2011).

In terms of Strategy and Corporate Governance, these issues scientifically emerged in the 1970s when Mace (1971), Norburn and Grinyer (1974) and Pahl and Winkler (1974) adopted theoretical perspectives, for example, the Agency Theory (Daily, Dalton, & Cannella, 2003; Eisenhardt, 1989; Fama & Jensen, 1983; Hendry & Kiel, 2004) and the Resource Dependence

Theory (Carpenter & Westphal, 2001; Goodstein, Gautam, & Boeker, 1994; Pearce & Zahra, 1991; Zahra & Pearce, 1989). Thus, the initial proposition (P1) of this research is that:

Proposition 1 (P1). There is an alignment between the Governance and Strategic Capacity.

Regarding Scenarios adoption, the primary interest for its involvement in this study is the fact that they allow detailed exploration of the critical uncertainties of a given system (Martins, Boaventura, Spers, Fischmann, & Costa, 2012). A scenario is not a future reality, but rather a means to represent it in order to clarify the present action in the light of possible and desirable futures (Durance & Godet, 2010).

Taking as an example the innovative and emerging solutions technologically produced within the TP, it is possible that with the ownership of future scenarios these organizations can stay ahead in a controlled manner, to future changes, designing and developing embryonic solutions, but that may be even more profitable to over time. Schoemaker and Mavaddat (2003) argue that emerging technologies are considered to be different from other forms of investment, since small innovations can produce, sometime later, major sectoral changes with social and economic impacts. Scenarios adoption is indispensable to strategy. In this sense, the proposition (P2) of this research is that:

Proposition 2 (P2). There is an alignment between Scenarios and Strategic Capacity.

Regarding Infrastructure adoption as this study construct, Carvalho (2013) points out that since the Egyptian, Chinese and Indian civilizations to contemporary times, many records testify to the strategic action of the infrastructure (hard and soft) in terms of: housing; locomotion; population life quality; way of stimulating economic development; social development improvement factor; interfederative connection instrument; interrelated with the government planning; fiscal adjustment policies protagonist; geopolitical influence tool by foreign countries.

Economist Intelligence Unit [EIU] (2015) report, an entity linked to The Economist, and the Hong Kong and Shanghai Banking Corporation [HSBC], pointed to limited infrastructure as a factor that more negatively influences in the organized ranking by the countries business environment institution.

Wessner (1999) argues that it is essential the TP be provided with a capable and sufficient infrastructure to create opportunities, promote cooperative development, and promote the marketing and attracting of new business. Studies point to the TP infrastructure as a resource and its lack as a barrier to be overcome (Su et al., 2009; Xue, 2007). The infrastructure deficiency, according to Chen and Yu (2008), Phan et al. (2005), Chan and Lau (2005), and Zhou, Xu, Jun and Minshall (2011), is a major obstacle to the establishment, growth and development of the potential TP. The infrastructure can be accepted as a strategic resource. Therefore, the third proposition (P3) of this research is that:

Proposition 3 (P3). There is an alignment between the Infrastructure and Strategic Capacity.

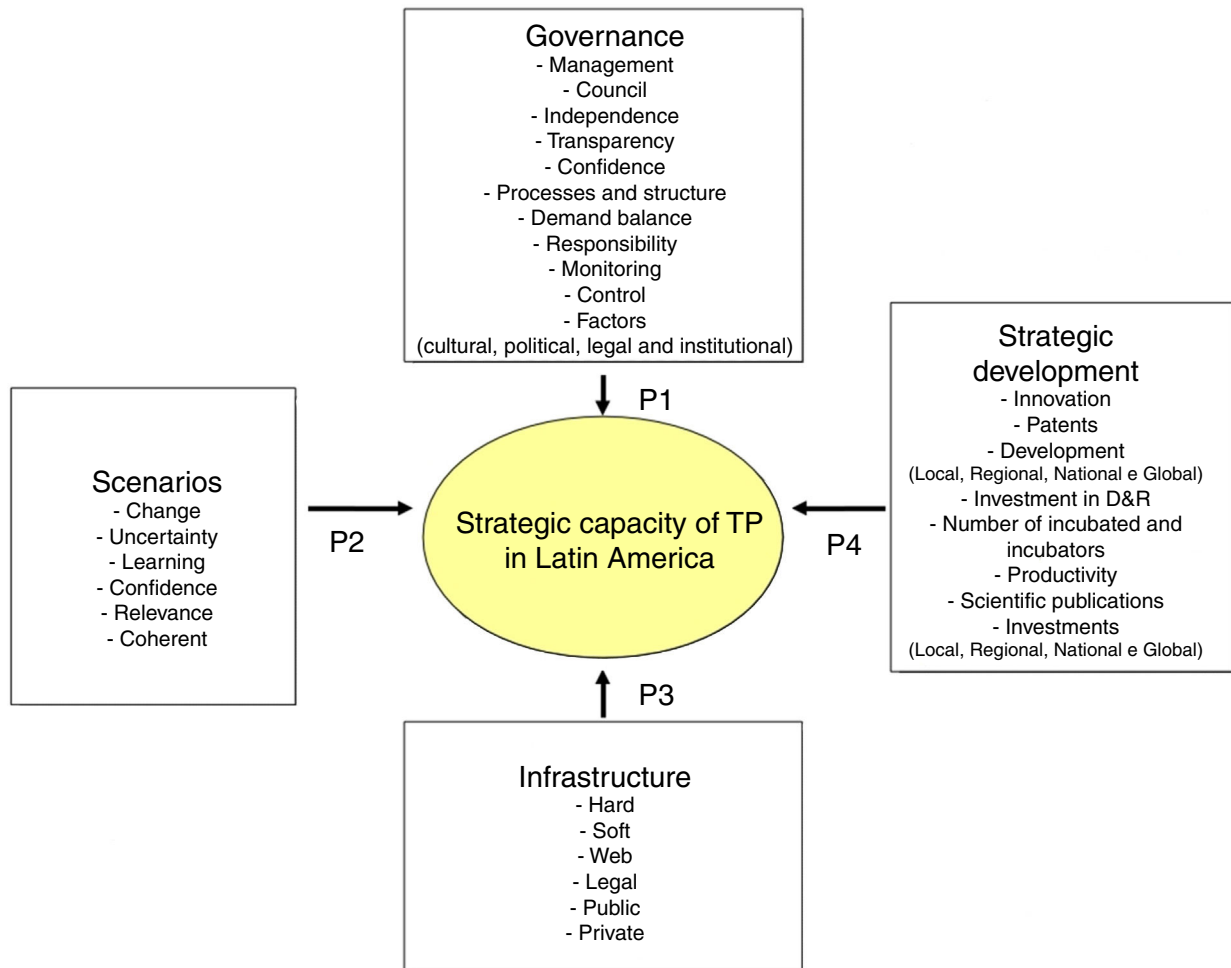


Fig. 1. TP Strategic Capacity Index analysis framework.

Source: Elaborated by the authors.

Organizational actions mark of efficiency and effectiveness is a result of their strategic performance. For this reason, the last dimension adopted as related to strategic capacity of Latin America TP is the strategic performance. According to Albahari, Catalano and Landoni (2013, pp. 601–602), TP performance gives up primarily by: (1) TP participation in regional economy; (2) TP impact in innovation generating; and (3) TP impact in regional development. This and other variables were parts of framework proposed formation. In this horizon, we have the fourth proposition (P4) of this research:

Proposition (P4). There is an alignment between the Strategic Performance and Organization Strategic Capacity.

For Miao et al. (2015), Nauwelaers et al. (2014), Rowe (2014), Giugliani (2011) and Zouain (2003), TP, while complex projects and permeated by different actors, which are: (i) stakeholders: universities; research institutes; business incubators; technology-based companies – business centers; service centers and coexistence; companies or learning-intensive industries; public sector, at all levels (Federal, State and Municipal); government agencies; developers and investors; business partnerships; banks and/or investors of venture capital and capital;

(ii) shareholders; lenders or investors; are institutions that need to evolve under review.

Given this **gap**, after a preliminary theoretical survey follows Fig. 1 with a 4 dimensions framework proposal (Infrastructure, Scenarios, Corporate Governance and Strategic Performance), its 31 indicators that guide the following propositions that can corroborate the evaluation of Latin America TP.

- (1) Proposition 1 (P1): There is an alignment between the Governance and Strategic Capacity (Bianchi (2005); Bhagat and Black (2000); Dalton, Daily, Ellstrand and Johnson (1998); Demsetz and Lehn (1985); Eisenhardt (1989); Freeman (1984); Jensen and Meckling (1976); Unesco-Wta. (2010); La Porta, Lopez-De-Silanes and Shleifer (1999); Rechner and Dalton (1991); Shleifer and Vishny (1986); Shleifer and Vishny (1997));
- (2) Proposition 2 (P2): There is an alignment between Scenarios and Strategic Capacity (Burt et al. (2002); Burt and Van Der Heijden (2003); Chermack (2011); Chermack, Lynham and Van Der Merwe (2006); De Geus (1999); Godet and Roubelat (2000); Jouvenel (1999); Schwartz (1996); Wack (1985));

- (3) Proposition 3 (P3): There is an alignment between the Infrastructure and Strategic Capacity (Bowker, Baker, Millerand and Ribes (2010); Buhr (2003); Carvalho (2013); Edwards, Jackson, Bowker and Knobel (2007); Engeström (1990); Fourie (2006); Jochimsen (1966); Star and Ruhleder (1996); Stohler (1977); Torrisi (2009); Tuchtfeldt (1970), UNESCO-WTA. (2010); Villar Ezcurra (2001); Weber and Alfen (2010));
- (4) Proposition 4 (P4): There is an alignment between the Strategic Performance and Strategic Capacity (Bigliardi, Dormio, Nosella and Petroni (2006); Hu, 2007, Kihlgren (2003); Landoni, Scellato and Catalano (2010); Lee and Yang (2000); Leyden, Link and Siegel (2008); Link and Scott (2003); Löfsten and Lindelöf (2001, 2002, 2003); Siegel Westhead and Wright (2003); Vedovello (1997); Yang, Motohashi and Chen (2009)).

TP strategic capacity theoretical framework proposal

Framework is associated to a representation idea of something that wants to be reproduced. A form or pattern is capable of having reference function and operate as a prescription for agents who make decisions about practices to be employed in organizations field (Zibolvicius, 1999).

Most of the TP researches only address theoretical issues, context, policies, feasibility, regional development, national and international investment and relationships with various stakeholders (Albahari et al., 2013; Bower, 1993; Chan & Lau, 2005; Gainoa & Pamplona, 2014; Lee & Yang, 2000; Löfsten & Lindelöf, 2002; Phan et al., 2005; Wield & Massey, 1992; Yang et al., 2009), among others, but studies, indicators or consolidated systemic frameworks involving the strategic capacity are not known.

Despite all plurality, complexity and difficulty of identifying the relevant factors to achieve organizational efficiency and effectiveness of TP, this proposal follows the challenge to meet the strategic capability level of the TP in Latin America through its dimensions and indicators as presented. The next section presents a set of methods and techniques to assist or support people and organizations to take action. These funds will be proposed as technology helps to consolidate this study framework.

Methodology

According to Forte (2006), statistical methods predominate in quantitative research, while categorizations and more essay analysis score in qualitative research. “Anyway, as always, there will be phenomena explanations, calculations and quantitative results, research has itself both methods” (Forte, 2006, p. 7). It

should be noted that there is no superiority of one type of research over the other on the use of qualitative or quantitative techniques, which depends on the researcher’s ability to adapt them to your needs. In Table 1, a research classification example is verified.

Based on the foregoing, it can be said that through variables nature, this study is classified as a qualitative and quantitative research (Creswell, 2009). The qualitative component, from exploratory character, according to Creswell (2009), aimed to identify the essential factors to assess the strategic capacity through literature; according to Lakatos and Marconi (2010), the literature is the literature review that is already published by through electronic consultation on the various bases of national and international data – SI Web of Science; Scopus; ProQuest; CAPES; Academic Search Premier – ASP [EBSCO], ScienceDirect [Elsevier], SpringerLink [MetaPress]. As a complement, the descriptive character quantitative component sought to describe the phenomenon called strategic capacity and to explain it by studying the variables, factors and involved criteria, and so suggest their subsequent standardization, validation and definition of a Latin America TP ECI, considering Bana e Costa and Vansnick (1995) observations, through MACBETH prescriptive and constructivist approach, and with the help of the Software M-Macbeth (Macbeth, 2015).

Also, interviews with 10 leading decision makers (representatives, directors, superintendents and coordinators) of the main Latin America TP (Brazil, MAXIMUM, Argentina, Colombia, Venezuela, Chile, Uruguay and Peru) were conducted.

Framework proposed multi-criteria support consolidation

The Multicriteria Decision Support (MDS) is, according to Gomes, Leta and Pessolani (2003), a set of methods and techniques to assist or support people and organizations to make decisions when there is the presence of a multiplicity of criteria.

Before applying any multi-criteria analysis method, it is necessary to establish clearly what is the purpose of the analysis, namely what the decision maker wants to achieve when wanting to compare each other’s decision alternatives resorting to using multiple criteria.

We propose in this study through TPs, the subsequent TP framework Strategic Capability Index consolidation through subjective value judgments legitimation and present in all decision making. In TPs, the makers values structure is associated to the existing and used criteria in the alternatives evaluation (Yu, 1985).

For a better explanation, there is Gomes, Gonzalez-Araya and Carignano (2004). According to the authors, the steps for multi-criteria analysis decision involve:

Table 1
Research classification.

1 – As for the Nature of the Variables	Qualitative	Quantitative	
2 – As for the Goal and the Problem of Grade	Exploratory	Descriptive	Causal
3 – As for Scope (Breadth and Depth)	Case Study	Field Study	Sample Survey
4 – As for Control	Laboratory	Field Trial	

Source: Forte (2006).

- (1) Identify the decision makers and their goals: individuals who make choices and take preference, as a single entity, also called agent or decision maker;
- (2) Set the alternative: global actions, which means, actions that can be evaluated in isolation. May represent different courses of action, different assumptions about a feature nature, different sets of features, etc.;
- (3) Identifying the relevant criteria for the decision problem: the criteria are the tools that allow actions comparison in relation to particular views (Roy, 1985). Bouyssou (1990) defines more precisely criterion such as a real-valued function in the set “A” of the alternatives, so that it is meaningful to compare two alternative “a” and “b” in accordance with a particular view, or the qualitative or quantitative expression of a viewpoint is used in the evaluation of alternatives;
- (4) Evaluate alternatives against the criteria: can be divided into a partial actions evaluation phase (alternatives) according to each viewpoint (criteria), and an overall assessment phase considering the various partial assessments. To conduct the evaluation is necessary to choose one of the available methods, traditionally classified into multi-attribute problems methods (deal with discrete alternatives) and multi-objective (consider a continuous space of alternatives);
- (5) Determine the relative criteria importance: structure and determine the importance attached to one criterion over another, from the adoption of the best methods and functions;
- (6) Conduct a comprehensive assessment of each alternative: the overall value of each alternative can be interpreted as a criterion which summarizes the performances by all criteria;
- (7) Sensitivity analysis: examining how sensitive the chosen alternative is if the variables involved in the decision model change. This helps the decision maker to visualize possible paths for any unforeseen situations;
- (8) Recommendation: recommend courses of action to be followed;
- (9) Implementation: implement the courses of action.

Overall, conventionally up as problems, Structuring Phase is steps 1, 2 and 3. At this stage, it is possible to learn and debate mainly by its interactivity, dynamic and common language among decision makers. However, according to Bana e Costa et al. (2000), this stage represents about 80% of the total problem. Steps 4, 5, 6 and 7 make up the Assessment Phase, which aims to apply multi-criteria analysis methods to support the modeling of preferences and their aggregation. The third phase, consisting of the steps 8 and 9, is the recommendation phase of the courses of action to be followed. Gomes et al. (2004), regarding step 3, warns that in a complex decision problem, the criteria may be structured as a hierarchy or tree in which the higher level criterion is decomposed into more detailed levels.

How to explain the decision maker's preference structures varies. To consolidate the Latin America TP strategic capacity index recommends a method that can be considered as the American multi-criteria school (Gomes et al., 2004; Gomes, 1999; Pomerol & Barba-Romero, 2000), mainly because the goal is

to construct a single index aggregating by weights means (also called constant scale or replacement rates), forming their dimensions. The suggested method is Measuring Attractiveness by a Categorical Based Evaluation Technique [MACBETH].

MACBETH

MACBETH is the method developed by Bana e Costa and Vansnick, 1995; Bana e Costa and Vansnick (1995, 1997) and presented in Bana e Costa, De Corte and Vansnick (2003); Bana e Costa, De Corte and Vansnick (2004) and Bana e Costa and Chagas (2004). MACBETH allows aggregating the various evaluation criteria into a single synthesis criterion by assigning weights to various criteria, respecting the decision makers' opinions.

Criteria weights are assigned with the alternatives attractiveness pairwise comparison, namely: given two alternatives, the decision maker must say which is the most attractive (must receive the highest score) and what degree this attractiveness has in a semantic scale that has correspondence with an ordinal scale (0≡indifferent, 1≡very weak attractiveness difference, 2≡weak attractiveness difference, 3≡moderate attractiveness difference, 4≡strong attractiveness difference, 5≡very strong attractiveness difference and 6≡extreme attractiveness difference).

Through M-Macbeth software (Macbeth, 2015) there is a computer method implementation, carrying out the trials analysis consistency and, in case of inconsistency, it is suggested how to resolve it. A rating scale is suggested by linear programming as well as their ranges without making the inconsistent problem (Unfeasible Linear Programming Problem). It is possible for the decision maker to adjust the value graphically of allocated grades, within allowable ranges (sensitivity analysis). Only after this adjustment, with the experts knowledge introduction, the value cardinal scale (quantitative) construction is characterized (Bana e Costa & Vansnick, 1997).

The MACBETH methodology consists of four mathematically linear programming problems (CPPs) sequence: (1) PPL 1 – Problem Mc1: performs the cardinal consistency analysis; (2) PPL 2 – Problem Mc2: responsible for building the cardinal value of scale; (3) CPPs 3:04 – Problems Mc3 and (4) MC4: reveals inconsistency sources.

Operationally, Bana e Costa and Vansnick (1995) propose the construction of judgments arrays to facilitate the expression of absolute judgments of attractiveness between pairs of stocks difference. Each X_{ij} element of the array takes the value k ($k = 1, 2, 3, 4, 5, 6$) if the decision maker decides that the pair's attractiveness difference (a_i, a_j) belongs to the class C_k . These numbers have no mathematical meaning and only serve as semantic indicators in which category of attractiveness difference was attributed to the respective pair.

From the foregoing, it executes MACBETH methodology, initially for any inconsistencies checking and then determining a cardinal scale value representing the decision maker's judgment value (expertise). The obtained scale is normalized, providing the evaluation alternatives weight values, which allows the use of an aggregation model generally additive.

Discussion and results

Latin America has a lot to do in terms of Regional Innovation System. With regard to TP, after Brazil, the first unit in Latin America emerged in Colombia (Antioquia) and dates back to 1998. Just to give an example, in a country with Peru's dimensions, the TP still's are in the consolidation process.

This study results shows that in Latin America the TP development policies are far from reaching their objectives with little impact initiatives in terms of TP. It should be noted, however, that in less than 20 years the TP total went from almost nothing to about 170 parks in different stages of development (operation, execution or planned) in Latin America. Most TP began their operation after 2000 (Agapitova, Holm-Nielsen, & Vukmirovic, 2002; Gil-Serrate, 2014; Llisterri & Pietrobelli, 2011; Rodríguez-Pose & Hardy, 2014).

Since this is an index construction proposal, the result is the own Framework (shown in Fig. 1) and the MACBETH method application proposed as further consolidation activity.

Compared to MACBETH, it is noteworthy, as presented, a special attention to the modeling phases for effective content validation. The first stage of a multi-criteria modeling is the structure phase, composed of three stages. At 1st step the decision-makers and their objectives will be identified. It is suggested as decision maker the TP expertise (board member, manager, etc.) to issue judgments about the difference in attractiveness between the evaluated dimensions. The aim of the decision maker is to generate a single output index that adds the generating dimensions of Latin America TP Strategic Capacity. At this stage the actions to be evaluated are identified. This actions family should be a coherent family, that is, must be cohesive, not redundant and exhaustive. From phase 2, the MACBETH multi-criteria method will support the preferences modeling and appropriate mergers.

The aspects considered more important to the development of the *framework proposal for review of the Strategic Capacity of Technological Parks in Latin America* are better visualized with the structure in "tree of values", where the points of view that interest in the evaluations of what is sought will reflect on the decision-making in every situation, by using the options to achieve the purpose (Bana e Costa, De Corte, & Vansnick, 2015).

The options used in the model were the 10 TP represented in the survey. Of the 31 indicators used as "criteria nodes", the *Governance* factor nodes had the highest weights (between 3.28 and 5.0). *Scenario* factor nodes had the second best weights (2.41–3.10), followed by the *Infrastructure* factor nodes weighing between 1.04 and 2.24. Finally, *Strategic Performance* factor nodes had the lowest weights (0.17–1.22).

The calculated results show that the overall score of the TP options from Brazil, Argentina and Chile had overall scores in the range of 80.0.

The positioning in terms of contribution and feasibility for each option and criteria lead to classify them as: (1) practices with high input and high feasibility; (2) practices with high contribution and hard to feasibility, but in case of elimination of implementation difficulties could become references; (3) low

contribution practices, but easy to implement. In some contexts these practices should not be discarded because they could be complemented with other practices to obtain benefits in the short term; and (4) rare practices that have low contribution and require more attention to implementation.

By using sensitivity, interactivity and robustness analyses it can decide and recommend as priority practices with greater contribution and work toward creating the necessary conditions for the implementation/feasibility of the practices that proved to be a lesser share. Through this analysis, the "Management" criteria, "Council" and "Independence" were selected by most decision makers of all options (10 TP).

Conclusion

This article presents a first approach to study the relative importance of Latin America TP Strategic Capacity forming dimensions, with the possible support models of Operations Research, namely, models MDS, in order to generate a TP strategic capacity index. From the literature developed along this research, it was theoretically possible to propose Latin America TP Strategic Capacity Index Analysis Framework that, after MACBETH method application, represented an effective measure of comparison. The survey represents a contribution toward inter-relate the use of strategic capacity indicators within the TP with Corporate Governance, Scenarios, Infrastructure and Strategic Performance.

After the questionnaires and analysis of results obtained through the options studied, it was evidenced by the overall score obtained by Latin Americans TP considered in the study, that if the TP get an average (score) over than 80 points, it can be considered that it presents strategic capacity to be economically sustainable, socially and environmentally. In the case where the score is below this average, it is necessary that plans for deficit practices can be remedied and that this TP has a differentiated strategic capacity. Brazil, Argentina and Chile were the geographic areas of reference in developing all aspects.

It appears that if the representatives, directors, superintendents and coordinators of TP in Latin America do not get a good performance on the criteria and factors considered in the model created in this study, in which they considered the characteristics and skills essential to the strategic capacity of Latin Americans TP and their respective criteria, the projects under their responsibility are less likely to be successful and sustainable, because the better grades options (above 80 points performance) were precisely the TP respondents who have shown good results.

However, it is believed that there is still much to be toward this end. Further research suggestions are applying MACBETH method in the proposed index consolidation, further exploration of cited theoretical references, as well as test content on field-work.

Conflicts of interest

The authors declare no conflicts of interest.

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