Pontifícia Universidade Católica
do Rio de Janeiro

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Measuring the innovation capacity and performance of organizations: A Balanced Scorecard approach combined with Analytic Network Process

Dissertação de Mestrado

Dissertation presented to the Programa de Pós-graduação em Metrologia of PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Metrologia.

Advisor: Prof. Maria Fatima Ludovico de Almeida

Rio de Janeiro
April 2021

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Rio de Janeiro, April 28th, 2021.

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Bibliographic data

Rocha, Wellington Luiz Leite da

Measuring the Innovation Capacity and Performance of Organizations: A Balanced Scorecard Approach combined with Analytic Network Process/ Wellington Luiz Leite da Rocha ; advisor: Maria Fatima Ludovico de Almeida. – Rio de Janeiro: PUC-Rio, Programa de Pós-graduação em Metrologia, 2021.

99 f. : il. color. ; 30 cm

1. Dissertação (mestrado) – Pontifícia Universidade Católica do Rio de Janeiro, Centro Técnico Científico, Programa de Pós-Graduação em Metrologia.

Inclui bibliografia

1. Metrologia – Teses. 2. Gestão estratégica da inovação. 3. Métodos multicritério de apoio à decisão. 4. Balanced scorecard. 5. Indicadores e métricas. I. Almeida, Maria Fatima Ludovico de. II. Pontifícia Universidade Católica do Rio de Janeiro. Centro Técnico Científico. Programa de Pós-Graduação em Metrologia. III. Título.

CDD: 389.1

Acknowledgements

This dissertation is the milestone that ends a mission …and that opens the door to many others. We started this mission in 2019, and we are closing now in 2021. I say we (in the plural!) because I did not arrive, and I would never arrive here alone! And to those who were with me in body or spirit, those who brought me here, I thank you immensely...

First of all my little black girls, my wife Amanda and my daughters Laura and Gabriela, because they are the ones that provide me with the happiness and daily joy that sustains me, that inspire me to grow. I thank you for your patience for the hours that I needed to study and couldn't walk away or play. Ubuntu!

My teacher, advisor and partner Prof. Fatima Ludovico for sharing with me her strength, knowledge and determination to fulfill this mission. With her willingness to learn and to teach, she pushes us to be better and never give up. Gratitude!

To my friends and companions, Jéssica, Felippe and Ana Carolina, for all the support, encouragement in the work and studies and early mornings on this journey. You were very important! To my people from SóDúdú Bola for bringing me my roots and never allowing me to forget our equals, who I am! Axe!

To Jordão Energia and my co-workers (Pierre, Sara, Venilton, Marcio, Mariana, Ricardo, Rafael, Marcelo, Lora, Saulo, Natalia, Cleber, Vinícius, Caio, Augusto e George) who allowed me to take this flight, and land safely, in a relationship of trust, respect and good humor. It is a great satisfaction to be part of this team! Saravá!

I would like to acknowledge all teachers from the Programa de Pós-graduação em Metrologia (PósMQI/PUC-Rio) for their valuable guidance throughout my studies. Especially, I thank Prof. Rodrigo Calili for his lectures and advice in multicriteria decision-making methods, one of the methodological axis of my research.

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Abstract

Rocha, Wellington Luiz Leite da; Almeida, Maria Fatima Ludovico de (Advisor); **Measuring the Innovation Capacity and Performance of Organizations: A Balanced Scorecard Approach combined with Analytic Network Process.** Rio de Janeiro, 2021. 99 p. Dissertação de Mestrado – Programa de Pós-Graduação em Metrologia, Pontifícia Universidade Católica do Rio de Janeiro.

In the last decades, special attention has been paid to improving innovation capacity and performance measurement and evaluation models, and researchers have been defining new key indicators and factors behind the innovation performance throughout the innovation process. In light of the previous works carried out within the scope of Balanced Scorecard (BSC) theoretical framework and the multicriteria decision-making (MCDM) methods, this dissertation aims to propose a model for measuring and evaluating organizations' innovation capacity and performance adhering to the following principles: multi-dimensional structure, stakeholder goals orientation, cause-effect relationship analysis, innovation process orientation, and easy implementation and use. In line with these principles, the proposed model combines the BSC methodology with the Analytic Network Process (ANP) method in a hybrid methodological approach. It considers the interdependencies between the key innovation indicators classified according to the four perspectives of the BSC to calculate the global innovation capacity and innovation performance indexes. The applicability of this model could be demonstrated in the context of an innovative electricity generation company in Brazil. The conceptual model here proposed and the empirical results concerning an application in a corporate context may contribute to improving current innovation capacity and performance measurement practices. The integration of the ANP method into the BSC framework can be considered a differential in comparison to the current practices of measuring the innovation capacity and performance in organizations.

Keywords

Metrology; strategic innovation management; balanced scorecard; multicriteria decision-making methods; indicators and metrics.

Resumo

Rocha, Wellington Luiz Leite da; Almeida, Maria Fatima Ludovico de; **Modelo de medição e avaliação da capacidade inovativa e desempenho inovador de organizações: uma abordagem de Balanced Scorecard combinada com o método Analytic Network Process.** Rio de Janeiro, 2021. 99 p. Dissertação de Mestrado – Programa de Pós-Graduação em Metrologia, Pontifícia Universidade Católica do Rio de Janeiro.

Nas últimas décadas, atenção especial tem sido dada ao aprimoramento dos modelos de medição e avaliação da capacidade inovativa e de desempenho e novos indicadores-chave e fatores que influenciam o desempenho inovador das organizações têm sido objeto de pesquisa. À luz dos trabalhos anteriores realizados sobre a abordagem metodológica de gerenciamento estratégico conhecido como *Balanced Scorecard* (BSC) e métodos multicritério de tomada de decisão (MCDM), esta dissertação teve como objetivo propor um modelo de medição e avaliação da capacidade inovativa e desempenho inovador de organizações estabelecidas, que seja aderente aos seguintes princípios: estrutura multidimensional; definição dos objetivos estratégicos com envolvimento dos stakeholders; análise das relações de causa-efeito; orientação para o processo de inovação; e facilidade de implementação. Alinhado a esses princípios, o modelo proposto combina a metodologia BSC com o método *Analytic Network Process* (ANP) numa abordagem metodológica híbrida, que considera as interdependências entre os indicadores-chave de inovação classificados segundo as quatro perspectivas do BSC, para calcular os índices globais de capacidade inovativa (ICI) e desempenho inovador (IPI). A aplicabilidade deste modelo pôde ser demonstrada pela sua aplicação no contexto de uma empresa inovadora do setor elétrico no Brasil. O modelo conceitual aqui proposto e os resultados empíricos relativos a uma aplicação em um contexto corporativo podem contribuir para melhorar a capacidade de inovação atual e as práticas de medição de desempenho. A integração do método ANP ao arcabouço do BSC pode ser considerada um diferencial em comparação às práticas atuais de mensuração da capacidade de inovação e desempenho nas organizações.

Palavras-chave

Metrologia; gestão estratégica da inovação; *Balanced Scorecard*; métodos multicritério de apoio à decisão; indicadores e métricas.

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1 Introduction

Measuring, evaluating, and benchmarking innovation capacity and performance is a significant and complex issue for many organizations. Multiple factors determine the capacity of organizations to innovate, and generating and then converting new ideas into usable and marketable products requires a high degree of inter-functional and even inter-organizational coordination and integration (Adam *et al.,* 2006). In this context, innovative organizations enhance their general competence-base and stimulate learning processes, benefiting themselves and organizations belonging to other economic sectors. The innovation capacity refers to their ability to understand changes in business environments, grasp market opportunities, and create new knowledge and solutions internally or in collaboration with strategic partners.

Notwithstanding the well-known advantages of network relationships for these organizations, it is indubitable that they strongly influence strategic decisions concerning RD&I initiatives and innovation management operations. From this perspective, appropriate managerial tools for innovation capacity and performances are vital to innovative organizations working in RD&I networks, mainly because they can ease information flows among the various actors involved (Spanò *et al.*, 2016; Franco-Santos and Bourne, 2005).

According to the Oslo Manual (OECD, 2018), several organizational capabilities can potentially support innovation activities and the successful innovation introduction on the market or brought into use by the organization. Options for measuring capabilities that are relevant for research on the organizations' innovation performance are: (i) the resources controlled by the organization; (ii) its general management capabilities, including capabilities related to managing innovation activities; (iii) the human capital and how the organization manages it; and (iv) the ability to develop and use technological tools and data resources, with the latter providing an increasingly important source of information for innovation.

In this regard, special attention has been paid to improving innovation capacity and performance measurement models. Researchers have been defining new indicators and factors behind the innovation performance throughout the innovation process (Dziallasa and Blind, 2019).

As posed by Dewangan and Godse (2014), in the last decades, several multidimensional innovation performance measurement models have been designed to address this need. Most of these models attempt to combine financial and non-financial indicators to measure the organization's tangible and intangible assets and value. Some outstanding examples are the balanced scorecard (Kaplan and Norton, 1996; 2006) and the performance prism (Neely *et al.*, 2002).

Balanced Scorecard (BSC) has been used by organizations for monitoring and evaluating their performance strategically. It is a methodological approach to determine business performance by means of lead and lag indicators aligned to their vision, mission, and values statements. This approach is based on the assumption that business performance should be evaluated considering both financial and non-financial indicators.

To measure and evaluate the innovation capacity and performance at the organization level, the BSC approach can be considered a proper measurement and managerial framework, but only if there is a reasonable attempt to adapt the original framework. The required methodological adjustments refer mainly to the insertion of strategic innovation goals, key indicators, and metrics associated with them within each of the BSC perspectives (Gama *et al.*, 2007; Spanò *et al.*, 2016).

From the literature review, 28 empirical studies published from 1988 to 2020 were identified and summarized in Table 2.1. Of that total, 15 studies employed the scorecard approach, adapting the original conceptual framework conceived by Kaplan and Norton (1996; 2006) to include specific innovation strategic goals and associated key innovation indicators and metrics, classified according to four BSC perspectives. One can distinguish two streams in these studies: (i) the first focuses on the innovation performance (Gama *et al.*, 2007; Spanó *et al.*, 2016; Ivanov and Avasilcai, 2014; Dewangan and Godse, 2014; Dudic *et al.*, 2020); and (ii) the second emphasizes the measurement and evaluation of R&D outcome and processes (Bremser and Barsky, 2004; Ojanen and Vuola, 2006; Chiesa *et al.*, 2009; Lazzarotti *et al.*, 2011; and Bican and Brem, 2020). Gama *et al.*, 2007; Spanò *et al.*, 2016). These contributions will be discussed in-depth in Chapter 2 to highlight the gaps in the literature on this field.

Although considerable efforts have been devoted to developing and applying models for measuring and evaluating innovation capacity and innovation performance based on the BSC framework, previous works have focused essentially on the adaptation of the original BSC model. Innovation and R&D indicators associated with BSC perspectives have also been proposed in these works. However, integrating multicriteria decision-making approaches into the BSC models, customized for strategic innovation management, has remained unknown to researchers and managers. Particularly concerning this issue, there are fundamental methodological differences between the results presented here and the previous studies reviewed in Chapter 2.

In the Brazilian context, in June 2019, the National Electric Energy Agency (ANEEL) opened a Public Consultation n. 017/2019, with the specific objective of obtaining subsidies to incorporate new instruments to encourage innovation in the electricity sector. In the Technical Note 227/2019 - SPE / ANEEL, three axes of discussion were proposed to guide the contributions to improve the ANEEL R&D Program. Specifically, the third axis focuses on the so-called 'regulatory innovation' with questions addressed to new management and implementation of solutions to increase the referred Program's effectiveness. In this regard, two questions were raised in the item "Criteria for assessing innovation in the electricity sector" of NT n. 227/2019 - SPE / ANEEL (2019, p.39):

- Question 33:How to assess the innovation capacity, and which indicators should be used to measure the innovation capacity and performance of a company in the electricity sector?
- Question 34: What are the most relevant results that companies in the electricity sector should present as an output of the application of compulsory investments in RD&I?

In view of the importance of the dynamics of technological and business models within the Brazilian electricity sector, it is believed that the proposed model can methodologically support the ongoing evolutionary process of the ANEEL R&D Program.

In this context, the dissertation was developed and supervised within the research line ‘Strategic Management of Innovation and Sustainability’ of the

Programa de Pós-graduação em Metrologia (PósMQI) da Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

1.1. Research problem definition

Considering that:

- An organization's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments lies at the center of its capacity to innovate (Teece *et al.*, 1997);
- Dynamic capabilities facilitate not only the ability of an organization to recognize a potential technological shift, but also its ability to adapt to change through innovation (Hill and Rothaermel 2003);
- The concepts of innovation capacity and performance are second-order constructions of innovation management, operationalized in the form of cause-effect relationships;
- The cause-effect relationships and feedback between elements of innovation capacity and performance constructs have been neglected in previous works;
- The literature review on measurement and evaluation of innovation capacity and performance reveals that previous works have focused essentially on the adaptation of the original BSC model and the identification of innovation and R&D indicators associated with BSC perspectives;
- Nowadays, the BSC approach is a methodological reference that guides organizations to determine their business performance employing leading and lagging indicators, aligned to their vision and business strategies;
- Integrating multicriteria decision-making (MCDM) approaches into the BSC models, designed for R&D and innovation management, has remained unknown to researchers and managers; and
- This combination (BSC and MCDM approaches) can contribute significantly to improving current innovation performance measurement practices;

The main questions addressed in this research are:

- How to measure and evaluate established organizations' innovation capacity and performance, adhering to the guiding principles of multidimensional structure, innovation process orientation, stakeholder goal orientation, cause-effect relationship analysis, and easy implementation and use?
- What are the key innovation indicators that should be considered in the BSC framework for modeling a process of measuring and evaluating innovation performance at the organization level?
- How to assign weights to the key innovation indicators, considering cause-effect relationships between them?
- What measurement scales should be integrated into the model to evaluate the organizations' innovation capacity and performance?
- To what extent can the application of the Analytic Network Process (ANP) method contribute to the efficiency of the innovation capacity and performance measurement at the organization level?
- Can the results of applying the model in the context of the Brazilian electric sector demonstrate the alignment of the model with the guiding principles and the benefits of the BSC approach for companies in this sector?
- Which are the main contributions of this research for the revision of the regulatory framework of the ANEEL R&D Program, focusing on the item ‘Criteria for assessing innovation in companies in the electric sector’ according to the ANEEL Public Consultation n. 017/2019)?.

1.2. General and specific objectives

With an attempt to answer these research questions, this dissertation aims to propose and apply a strategic measurement model to monitor and evaluate the innovation capacity (IC) and performance (IP) in established organizations, based on an adapted BSC framework combined with multicriteria decision-making (MCDM) approach.

In order to achieve the general objective, five specific objectives were defined, as follows:

- To discuss the importance of measuring and evaluating the innovation capacity (IC) and performance (IP) of established organizations, adhering to the guiding principles of multidimensional structure, innovation process orientation, stakeholder goal orientation, cause-effect relationship analysis, and easy implementation and use;
- To identify and analyze previous works on innovation capacity and performance measurement to identify research gaps and guiding principles for the modelling phase;
- To identify key innovation indicators that should be considered in the BSC framework for modelling a process of measuring and evaluating innovation capacity and performance at the organization level;
- To define measurement scales that should be integrated into the model to evaluate the organizations' innovation capacity and performance;
- To develop a conceptual model and a self-assessment instrument for measuring and evaluating IC and IP in organizations, that will be applied further in a real context – a company in the Brazilian electric sector;
- To develop an empirical study within a selected company in the Brazilian electric sector, aiming to demonstrate the applicability of the conceptual model and its benefits for this company and organizations in general;
- To contribute with subsidies for the revision of the regulatory framework of the ANEEL R&D Program, focusing on the item 'Criteria for assessing innovation in companies in the electric sector', according to the ANEEL Public Consultation n. 017/2019.

1.3. Methodology

According to Vergara (2002), the research can be considered applied, methodological and descriptive. The research adopted the following methodology: (i) literature review and documentary analysis on the central themes of research – innovation capacity and performance measurement; balanced scorecard approach; and potential application of multicriteria decision-making methods in BSC models; (ii) definition of the network analytical structure, according to the Analytic Network Process (ANP) method, following the basic structure of the BSC framework, adapted to strategic management systems within established organizations; (iii) identification and classification of key innovation indicators and use of the ANP method for assigning weights to them, through consensus-building sessions with specialists in innovation management and multicriteria decision-making analysis; (iv) elaboration and application of a self-assessment instrument in an innovative company operating in the Brazilian electric sector, based on the conceptual model to demonstrate its applicability and benefits.

Figure 1.1 presents the research design in its three broader phases: (i) exploratory and descriptive; (ii) applied research; (iii) conclusive. Next, the three phases of this research are described according to this schematic representation.

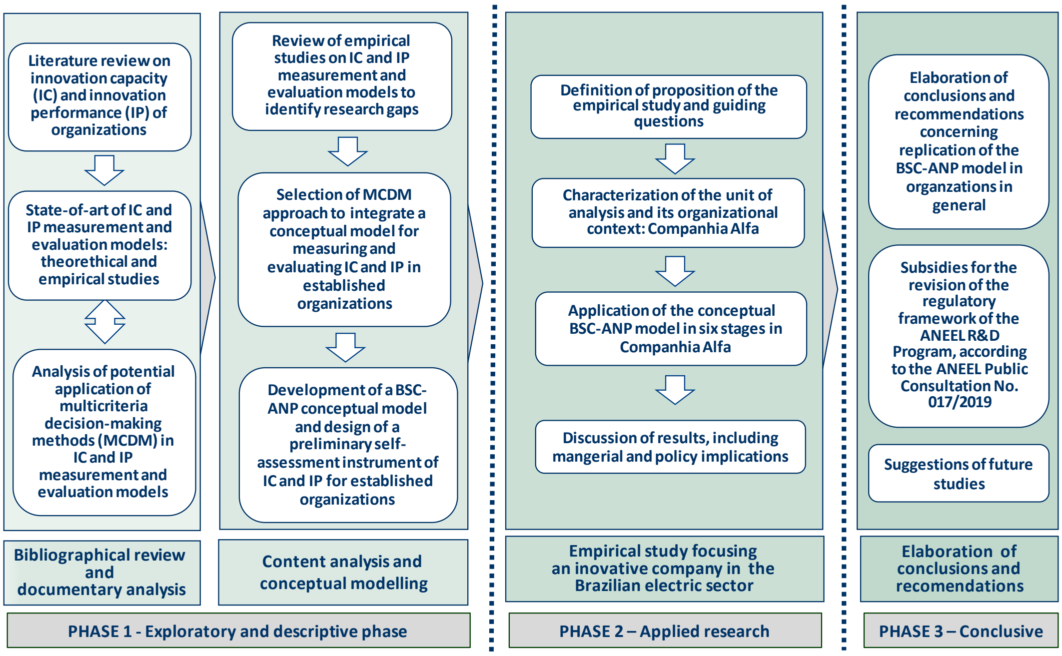

Figure 1.1 – Research design, its components, and methods
Source: Author's elaboration.

1.3.1.
Exploratory and descriptive phase

This phase started with bibliographic research and documentary analysis covering the period from 2000 to 2020 to raise conceptual works and reference documents related to the central themes of this research – innovation performance measurement, balanced scorecard approach, and multicriteria decision-making analysis. For this, systematic searches were carried out in the main scientific production databases (Scopus, WoS, Science Direct, and others), combining the keywords "innovation performance measurement"; "multicriteria decision-making method*" or "multiple criteria decision-making method*" or MCDM; and "balanced scorecard" or BSC.

These searches were complemented with subsequent searches on Google Scholar and the Scielo database, aiming to identify previous works on this theme carried out in the Brazilian context. Afterward, the bibliographic review was deepened, analyzing the references cited in the most relevant articles (backward search).

As a result, it was possible to identify 28 empirical studies which were compared according to their objectives, analytical structures for proposing innovation indicators and metrics, methodological approaches, and methods adopted. Then, focusing more specifically on methodological issues, it can be concluded that among the 28 studies, 15 adopted the scorecard approach (Kerssens-van-Drongelen and Cook, 1997; Wong, 2001; Verhaeghe and Kfir, 2002; Godener and Soderquist, 2004; Bremser and Barsky, 2004; Ojanen and Vuola, 2006; Gama *et al.*, 2007; Chiesa and Frattini, 2009; Lazzarotti *et al*., 2011, Mohamed, 2013; Dewangan and Godse, 2014; Spanò *et al*., 2016; Zhang, 2016; Bican and Brem, 2020; and Dudic *et al*., 2020).

Amongst the 15 studies that adopted the scorecard approach, one can distinguish two streams in these studies: the first focuses on innovation performance (Gama *et al*., 2007; Spanó *et al*., 2016; Ivanov and Avasilcai, 2014; Dewangan and Godse, 2014; Dudic *et al*., 2020), while the second emphasizes the measurement and evaluation of R&D outcome and processes (Bremser and Barsky, 2004; Ojanen and Vuola, 2006; Chiesa *et al*., 2009; Lazzarotti *et al*., 2011; and Bican and Brem, 2020).

Similarly, the other 13 empirical studies listed in Table 2.2 can be aligned with three general research streams: those focused on innovation performance (Kuczmarski, 2000; Muller *et al.*, 2005; Birchall *et al.*, 2011; Cruz-Cázaresa *et al.*, 2013; and Ivanov and Avasilcai, 2014); others emphasized the measurement and evaluation of R&D outcome and processes (Brown and Svenson, 1988; Cooper and Kleinschmidt, 1995; Griffin and Page, 1996; Suomala, 2004; and Adams *et al.*, 2006). In a third stream, some studies combined measurement and evaluation of R&D with innovation performance from a systemic perspective of innovation management (Collins and Smith, 1999; Milbergs and Vonortas, 2005; Dziallas and Blind, 2019). In contrast to the first group, the methodological approaches and methods adopted were diverse, encompassing content analysis, survey research, and case analysis.

The literature review allowed highlighting research gaps and the opportunity to develop a model based on the Balanced Scorecard framework, combined with a multicriteria method decision-making approach, to measure and evaluate the innovation capacity and performance of established organizations.

The theoretical framework served as a conceptual orientation for the research, providing the specialized vocabulary and organizing the knowledge base for the applied phase of the research.

In the next page, Figure 1.2 presents a general and schematic overview of the results of this first phase, in the format of a conceptual map of the research, with the main bibliographic references in each block of the map.

1.3.2. Applied research phase

In this phase, a conceptual model for innovation capacity and performance measurement and evaluation of organizations was developed based on the findings of the first phase. This conceptual model comprises six stages, as follows: (i) determination of the network model based on the BSC framework adapted to strategic management processes within established organizations; (ii) determination of the five-point scales for measuring innovation capacity and performance of established organizations and design of the self-assessment instrument by organizations; (iii) design and application of the questionnaire for pairwise comparisons of the network elements (i.e., key innovation indicators) and clusters (i.e., strategic innovation goals); (iv) determination of importance weights of network elements and clusters; (v) calculation of the limit supermatrix and resulting weights of the network elements; (vi) application of the self-assessment instrument and calculation of the Innovation Capacity Index (ICI) and Innovation Performance Index (IPI).

To demonstrate the applicability of the conceptual model proposed in the previous phase, an empirical study was developed within an innovative company in the Brazilian electric sector. This study followed the same steps is focused on Chapter 4.

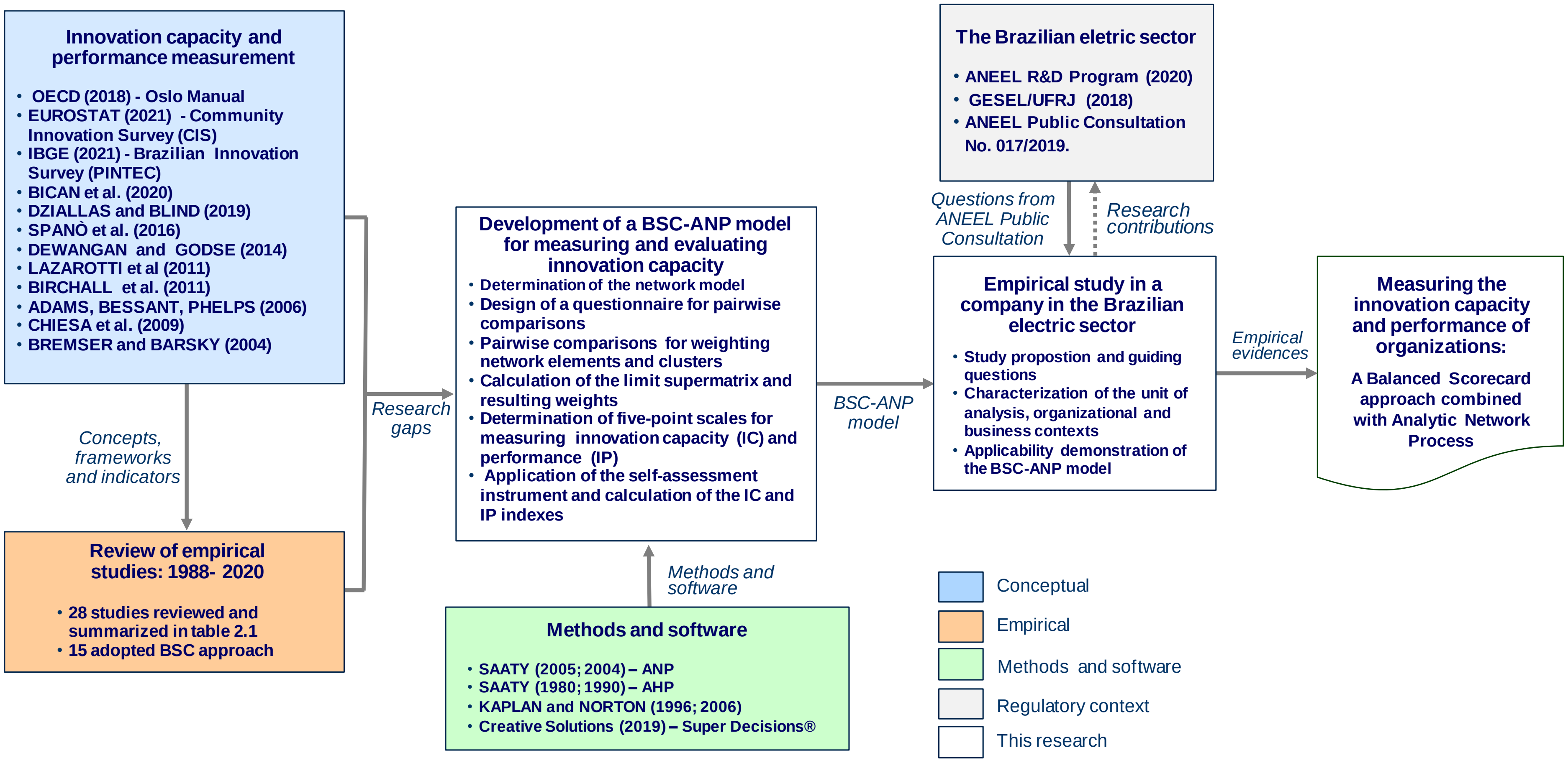

Figure 1.2 – Research conceptual map

Source: Author's elaboration.

1.3.3. Conclusive phase

In the third phase, conclusions were drawn in relation to each of the objectives stated in Section 1.2, emphasizing the benefits of this research to stakeholders, namely: (i) organizations in general and, in particular, the company in the Brazilian electric sector that agreed to participate in the applied phase of this research, during the development of the empirical study; (ii) the National Electric Energy Agency (ANEEL), which is seeking subsidies for the revision of the regulatory framework of its R&D Program, focusing on the item ‘Criteria for assessing innovation in companies in the electric sector’, according to the ANEEL Public Consultation n. 017/2019; and (iii) institutional actors, such as Science, Technology and Innovation institutions (CT&I) and the Brazilian Association of Electricity Distributors (ABRADEE), to name a few examples. Proposals for future deployments of this research were also formulated at this stage.

1.4. Structure of the dissertation

The dissertation is structured in five chapters. Following this introduction, Chapter 2 briefly presents the research methodology.

In Chapter 2, innovation performance measurement models developed for established organizations are analyzed and compared. To identify the gaps in the literature on this topic, the results of the analysis of 28 empirical studies, published between 1988 and 2020, are presented. This review allowed to highlight the opportunity to develop a model based on the Balanced Scorecard framework, combined with a multicriteria method decision-making approach, to measure and evaluate the innovation capacity and performance of established organizations.

Chapter 3 introduces the conceptual model for measuring and evaluating innovation capacity and performance in established organizations, aligned with the guiding principles of multidimensional structure, innovation process orientation, stakeholder goal orientation, cause-effect relationship analysis, and easy implementation and use. The Analytic Network Process (ANP) method (Saaty, 2004; 2005) was integrated into the conceptual model based on the BSC framework (Kaplan and Norton, 1996; 2006) adapted to strategic management processes within established organizations.

In Chapter 4, the results of an empirical study carried out with one of the companies in the Brazilian electric sector (SEB) are reported and discussed, aiming to demonstrate the applicability of the proposed model within a real organizational environment and to contribute with subsidies for the revision of the regulatory framework of the ANEEL R&D Program, focusing on the item 'Criteria for assessing innovation in companies in the electric sector', according to the ANEEL Public Consultation n. 017/2019.

Finally, Chapter 5 synthesizes the concluding remarks and future deployments of this research.

2
Measurement and evaluation of innovation capacity and performance of organizations: a literature review

Initially, six established models for measuring and evaluating innovation management in organizations, in general, were analyzed and compared. In the sequence, 28 empirical studies on the theme were analyzed, aiming to identify the methodological approaches adopted and to highlight the research gaps to be considered in the modeling stage. The results of the analysis of 28 empirical studies published between 1988 and 2020 are presented, allowing to highlight opportunities to develop a model based on the Balanced Scorecard framework, combined with a multicriteria method decision-making approach, to measure and evaluate the innovation capacity and performance of established organizations. In this review, the epistemological line adopted by Dewangan and Godse (2014) was considered relevant to the modeling phase, particularly the five guiding principles proposed by the authors, according to a systemic and strategic view for a successful model for innovation management measurement. These principles are presented and discussed in more detail in item 2.2.

2.1. Innovation management measurement models

Within the literature on innovation management, measures of aspects of innovation management are frequently proposed, responding to the needs of organizations in general, academics and policy-makers to understand the effectiveness of innovation actions. Table 2.1 presents six broadly used innovation management measurement systems as the basis for further discussion on empirical studies concerning innovation capacity and performance measurement. They are Innovation Scoring (COTEC, Portugal); IMP3rove (European Community); InnoScore (Fraunhofer Institute, Germany); Bússola da Inovação (FIEP, Brazil); PWC's Strategy Co; and McKinsey.

Table 2.1 – Comparative analysis of six broadly used innovation management measurement models

Model	Data collection instrument	Analysis unit	Analysis dimensions and variables	Data analysis and evaluation of results	Presentation of results
Innovation Scoring (COTEC, 2021)	Questionnaire structured in 5 sections	Firm	43 questions classified in 13 subgroups and 4 dimensions: conditions; resources; processes; and innovation output.	Analysis using a double scale (Approach and Application) and using the Likert scale (from 0 to 4).	Summary table, Innovation Scoring by dimension; positioning of Innovation Scoring; and self-diagnosis
IMP3rove (IMP3rove, 2021)	Structured online questionnaires composed of four modules	Firm	47 questions classified in five dimensions: innovation strategy; innovation organization and culture; innovation lifecycle processes; enabling factors; and innovation output.	Self assessment, comparison with industry average and with 10% better, varying by module.	Percentage of innovation management capacity (average); composite radial graph; horizontal bar charts.
InnoScore Service (Freitag and Ganz, 2018)	Online form (in German)	Firm	31 questions classified in nine innovation management dimensions	Self-assessment and benchmark comparison.	Bar diagram with data comparison with benchmark.
Bússola da Inovação (FIEP, 2021)	Online self-assessment survey	Firm	Ten innovation management dimensions.	Self-assessment, on a scale of 0 and 4, indicating the level of development of each dimension. Presented in radar format.	Individual analysis report with tips and recommendations and Radar chart.
PWC's Strategy Co (PWC's Strategy Co, 2021)	Self-assessment questionnaire	Firm	Three auto-assessment tools: Innovation Strategy Profiler, Innovation Accelerator Tool, Strategic Intuition Diagnostic Profiler.	Each tool has its own form of analysis: scale from 1 to 5, multiple choice and others.	Benchmark report with quantitative and practical examples.
McKinsey (McKinsey, 2021)	Self-assessment questionnaire	Firm	Two self-assessment tools: Growth Decomposition Tool and Eight Essentials of Innovation Diagnostic Tool with a total of 104 questions.	Self-assessment and benchmark comparison.	Report with results of the diagnosis .

2.2. Innovation capacity and performance measurement models: empirical studies

To complement the comparative analysis of five established innovation management models, a literature search was conducted, focusing more specifically on previous studies that had employed the systematic literature review (SLR) approach to investigate this research field. This search has yielded several reviews, but only three were selected as an initial step of the literature review: Adams *et al.*, 2006; Dewangan and Godse, 2014; and Bican *et al.*, 2020. An in-depth analysis of these articles, including backward citation search and a new search in the Scopus, Web of Science databases, made it possible to identify 28 empirical studies, presented in Table 2.2. They were compared according to their analytical structures for proposing innovation indicators and metrics, methodological approaches, and methods adopted.

Gama *et al.* (2007) proposed an Innovation Scorecard (ISC), based on the traditional BSC, that measures the value created by innovation projects and guarantees those projects are aligned with the organization strategy. Their model is based on innovation metrics defined before the project is evaluated (and then eventually approved) in order to help the project create the intended benefits. When the project is implemented, the chosen metrics are used to measure the value added by that innovation project to the organization's overall value.

Spanò *et al.* (2016) developed an innovation-oriented BSC to show the potential of this integrated theoretical approach to innovation, measurement, and control. Their study defines specific key performance areas and indicators to enrich each of the four BSC perspectives with the innovation elements that are only implicitly considered in the original model. The authors show the potential of the BSC to achieve a practical and effective interplay between innovation and control. This rationale was considered for defining the analytical structure of the conceptual model proposed in their paper.

Table 2.2 – Summary of empirical studies on innovation capacity and performance measurement models

Ref.	Author(s) (publication year)	Objectives	Analytical grid for measuring innovation performance	Methodological approach and methods adopted
R01	Brown and Svenson (1988)	To propose an R&D productivity measurement model, avoiding the errors identified in previous models.	R&D productivity measurement: inputs, processing system, outputs, receipt system, and results.	• Content analysis. • Research in secondary sources (data gathering).
R02	Cooper and Kleinschmidt (1995)	To analyze the results of a benchmarking study covering 135 companies on the general performance of new products, highlighting success factors that are not readily apparent from the evaluation of specific RD&I projects.	Performance measurement in two dimensions: impact of a new product program, and profitability of a new product program.	• Principal Component Analysis (PCA) • Varimax Rotation • Benchmarking analysis.
R03	Griffin and Page (1996)	To test hypotheses about the most appropriate set of measures to assess product development success at the RD&I projects and the new product program levels.	Performance measurement: customer-based success; financial success; and technical performance success.	• Survey research (data gathering). • Sensitivity analysis.
R04	Kerssens-van Drongelen and Cook (1997)	Assess the impact of R&D performance measurement in relation to the overall business performance within the context of global performance evaluation and the theory of independence.	R&D performance measurement: use of the balanced scorecard approach built according to key dimensions and requirements for a basic R&D performance measurement system.	• Research in secondary sources (data gathering). • Survey research (data gathering). • Interviews (data gathering). • Scorecard approach.
R05	Collins and Smith (1999)	Propose a balanced set of indicators and metrics to be applied in a six-step process, aiming to boost systemic innovation in an organization.	Key indicators and learning indicators, lag and real time indicators, classified in the dimensions: stakeholder strategies, processes, resources and culture for innovation.	Innovation management methodological approach as proposed by Arthur D'Little.
R06	Kuczmarski (2000)	To propose a system of innovation performance indicators and metrics at the corporate level.	Innovation performance measurement: metrics of innovation performance (to measure the company's growth through innovation) and metrics of innovation management (which allow measuring the management and control of the innovation process).	• Research in secondary sources (data gathering). • Content analysis.

Table 2.2 – Summary of empirical studies on innovation performance measurement models (cont.)

Ref.	Author(s) (publication year)	Objectives	Analytical grid for measuring innovation performance	Methodological approach and methods adopted
R07	Wong (2001)	To propose a *scorecard* model for innovation management comprising indicators and metrics associated with knowledge exploration and exploitation as key processes for innovation.	S*corecard* model for innovation management based on the original BSC perspectives: financial, customers, internal processes, learning and growth.	• Scorecard approach.
R08	Verhaeghe and Kfir (2002)	To propose an innovation management measurement model based on a scorecard approach, considering ten assessment dimensions.	Ten dimensions: leadership, resources for innovation, systems, and tools, innovation process, R&D activities, technology transfer, technology acquisition, market factors, innovation performance, and networking.	• Research in secondary sources (data gathering). • Interviews with R&D managers (data gathering). • Scorecard approach.
R09	Godener and Soderquist (2004)	According to the scorecard approach, to propose an innovation management measurement system, demonstrating the main areas of use and impact of the results of measuring R & R&D performance and new product development.	Measurement system for innovation management according to the scorecard approach, covering the following dimensions: financial performance; clients satisfaction; processes management; strategic technology management; innovation; knowledge management.	• Research in secondary sources (data gathering). • Interviews (data gathering). • Scorecard approach.
R10	Suomala (2004)	To propose a measurement system for new product development according to the concept of 'conscious life cycle', introduced through a conceptual analysis that combines the 'product life cycle' thinking and the new product performance measurement.	Measurement focuses vary depending on the generation phase in the life cycle phase of a new product, namely: a feasibility study in the preliminary phases; product development; launch on the market; production phase; maintenance and technical assistance; further development and end of the life cycle.	• Research in secondary sources (data gathering). • Case study.
R11	Bremser and Barsky (2004)	To propose a system for measuring R&D performance, integrating the *Stage-Gate*® approach to R&D management with a Balanced scorecard.	Measurement of R&D performance in institutions, considering financial and non-financial aspects, combining the use of resources in R&D initiatives with strategic business goals.	• Scorecard approach • Stage-Gate® approach

Table 2.2 - Summary of empirical studies on innovation performance measurement models (cont.)

Ref.	**Author(s) (publication year)**	**Objectives**	**Analytical grid for measuring innovation performance**	**Methodological approach and methods adopted**
R12	Milbergs and Vonortas (2005)	To propose a system of indicators, according to four categories, each category representing a generation of innovation models (from the 1st to the 4th generation).	Indicator categories: input, output, processes and innovations (each category includes indicators and metrics representing models from the 1st to the 4th generation of innovation models).	According to four theoretical innovation models, field research (based on the analysis of the innovation metrics' evolution, according to four theoretical innovation models.
R13	Muller *et al.* (2005)	To propose general principles for the definition of innovation metrics and a set of specific and customizable metrics to track and promote innovation performance.	Measurement of innovation following a structure that combines three aspects: resources, innovation capacity, and leadership for innovation. The selection of indicators and metrics, as well as the ideal spot, will vary from company to company.	• Literature review. • Content analysis.
R14	Adams *et al.* (2006)	To present a summary with the most common metrics for innovation management at different stages of innovation management maturity.	Measurement of R&D process performance according to seven dimensions identified as typical in the literature: inputs, knowledge management, strategy, organization and culture, portfolio management of RD&I, management of RD&I projects, and commercialization of innovative solutions.	• Literature review. • Research in secondary sources (data gathering) • Delphi technique • E-mail survey (n=28)
R15	Ojanen and Vuola (2006)	To propose a new practical tool to visualize and categorize the dimensional aspects in the analysis of R&D performance and selection of indicators and metrics for R&D management.	Categorization of indicators and metrics according to: (i) measurement perspective; (ii) measurement purpose; (iii) measurement level; (iv) type of R&D activity; and (v) stage of the innovation process (innovation funnel)	• Scorecard approach.
R16	Gama *et al.* (2007)	To propose an innovation scorecard system based on innovation indicators and metrics, combined with the traditional BSC.	Measurement of the added value of innovation in each implemented project while ensuring its alignment with the organization's strategic goals.	• Literature review. • Scorecard approach. • Case study.
R17	Chiesa and Frattini (2009)	To propose a system for measuring the performance of R&D units, according to the scorecard approach and based on literature review and case studies.	Scorecard perspectives for innovation: financial performance; market orientation; efficiency of R&D processes; innovation capacity.	• Scorecard approach. • Survey research (data gathering) • Research in secondary sources (data gathering)

Table 2.2 – Summary of empirical studies on innovation performance measurement models (cont.)

Ref.	**Author(s) (publication year)**	**Objectives**	**Analytical grid for measuring innovation performance**	**Methodological approach and methods adopted**
R18	Lazzarotti *et al.* (2011)	To propose a conceptual model for measuring the performance of R&D activities based on a systemic and balanced structure of quantitative indicators grouped in five different performance perspectives.	Calculation of the performance of R&D activities, on two levels: (i) each of the five perspectives of the BSC and the R&D system as a whole; and (ii) performance of each indicator, measured on a scale of 1 to 5 (baseline and performance target to be achieved).	• Literature review. • Scorecard approach. • Case study.
R19	Birchall *et al.* (2011)	To analyze the relationship between innovation performance metrics at different stages of the innovation process and how the measurement system serves different organizations.	Measurement of innovation performance in three focuses: institutional, evolutionary and revolutionary innovation, which can also be divided in terms of the scope and nature of the measurement.	• Multicriteria decision-making approach.
R20	Cruz-Cázaresa *et al.* (2013)	To propose a new approach to deal with the relationship between innovation and performance, considering mixed and inconclusive results of studies that analyze this relationship.	Measurement of the efficiency of the technological innovation process considering: inputs (intellectual capital including highly qualified team) and output (number of product innovations and number of patents).	• Survey research (data gathering). • Data Envelopment Analysis (DEA)
R21	Mohamed (2013)	To determine the relationship between the characteristics of the BSC methodology and innovation measurement.	Correlation of the characteristics of the BSC and of the innovation measurement considering: diversity in the use of performance measures; the balanced use of performance measures; and the strategic link between performance metrics.	• Scorecard approach. • Survey research (data gathering). • Statistical analysis.
R22	Dewangan and Godse (2014)	To propose a set of guiding principles for modeling an innovation performance evaluation system and develop the model based on the scorecard approach.	Measurement and evaluation of innovation performance according to the four perspectives of the BSC: finance, customers, internal processes and innovation and learning. The indicators are also grouped by stage of the RD&I cycle.	• Literature review. • Scorecard approach. • Case study.

Table 2.2 – Summary of empirical studies on innovation performance measurement models (cont.)

Ref.	Author(s) (publication year)	Objectives	Analytical grid for measuring innovation performance	Methodological approach and methods adopted
R23	Ivanov and Avasilcai (2014)	To analyze the criteria of the four most important performance measurement models: BSC, Malcolm Baldrige, Performance Prism and EFQM and propose a model for measuring innovation performance based on the results of the analysis.	Performance measurement of the innovation process considering five dimensions: strategy, processes, leadership, competencies and organizational culture.	• Qualitative content analysis.
R24	Spanò *et al.* (2016)	To propose an innovation management measurement model based on the BSC approach to improve biotechnology companies' measurement and performance evaluation belonging to a knowledge-intensive and R&D network.	Measurement of innovation management according to an adaptation of the original scorecard approach (BSC by Kaplan and Norton). Perspectives: economic and financial; stakeholders; internal processes; and growth and learning.	• Literature and documentary review. • Interviews (data gathering). • Scorecard approach.
R25	Zhang (2016)	To propose an innovation performance measurement system based on the BSC to promote innovation, facilitating the development of competencies and providing guidelines for using the strategic management control system.	Measurement of innovation correlated with the results of the institution considering the BCS perspectives: learning and growth, internal processes, business, and customer service.	• Survey research (data gathering). • Scorecard approach.
R26	Dziallas and Blind (2019)	To define indicators for measuring the results in each stage of the innovation process based on Becheikh *et al.* (2006).	Measurement of innovation management performance considering 82 indicators and innovation factors.	Multicriteria decision-making approach.
R27	Bican and Brem (2020)	To survey the R&D performance measures in companies and propose the application of a mixed method composed of the main metrics as key for innovation performance measurement.	Measurement of innovation performance based on 154 R&D management measures, proposing 81 key indicators for measuring the company's innovation performance.	• Literature review. • Scorecard approach.
R28	Dudic *et al.* (2020)	To propose a model for assessing Innovative activities of small- and medium-sized firms in the Republic of Slovakia and the Republic of Serbia. To investigate the model's applicability in 223 SMEs in that country.	Innovation assessment based on the four BSC perspectives and 24 innovation indicators associated to each perspective.	• Scorecard approach. • Survey research with a multi-section questionnaire (data gathering) • Confirmatory factor analysis (CFA) • Structural equation modeling (SEM).

Source: Based on Adams *et al.* (2006); Dewangan e Godse (2014); Bican e Brem (2020); and Dudic *et al.* (2020) and also on searches in Scopus, Web of Science, and other databases. Note: Empirical studies that adopted a scorecard methodological approach are highlighted in gray.

Ivanov and Avasilcai (2014) identified key indicators within the organization that can be used to measure its innovation processes. The main contribution of this work is the analytical framework created by exploiting the key indicators of the organization used to measure the performance of innovation processes. The authors concluded that innovation indicators and metrics vary from sector to sector. The innovation indicators considered in this work will be considered in the empirical phase of this research.

Based on the BSC framework, Dudic *et al.* (2020) created and verified the validity of a modified BSC model and its applicability for evaluating and monitoring the innovative activities of small- and medium-sized enterprises in the Republic of Slovakia and the Republic of Serbia. First, they create a hypothetical model as a basis for designing a structural equation model (SEM model), using the results of a survey conducted simultaneously in both countries on a similar sample of enterprises (total of 223 enterprises). A set of 24 innovation indicators identified by the authors will be considered in the empirical phase of this research.

Following the second stream of thought, Bremser and Barsky (2004) explored integrated performance measurement systems that capture financial and non-financial performance. The authors integrated the stage-gate approach to R&D management with the BSC to present a framework to show how firms can link resource commitments to these activities and the firm's strategic objectives. They provided specific examples of how firms can apply this integrated performance.

Ojanen and Vuola (2006) constructed and presented a new practical tool for visualizing and categorizing the dimensional aspects in R&D performance analysis and the selection process of R&D indicators. The tool was developed in an iterative theory-building process with the help of a systematic literature review and long-term collaboration with a network of companies representing different industries. The emphasis of this study was on the necessary steps in the early phase of the selection process of R&D performance indicators. The authors pointed out that this phase includes recognition and careful consideration of the measurement needs with the help of the main dimensions of R&D performance analysis, such as: (i) the perspectives of the performance analysis; (ii) the purpose of R&D performance analysis; (iii) the type of R&D; (iv) the level of the analysis; and (v) the phase of the innovation process.

Chiesa *et al.* (2009) adopted a systemic and contextual perspective to look into the problem of measuring R&D performance. In particular, they explore the interplay between measurement objectives, performance dimensions, and contextual factors in the design of a performance measurement system (PMS) for R&D activities. Their work relies on a multiple case study analysis that involved 15 Italian technology-intensive firms. The results indicate that firms measure R&D performance with different purposes, i.e., motivate researchers and engineers, monitor the progress of activities, evaluate the profitability of R&D projects, favor coordination and communication and stimulate organizational learning. These objectives are pursued in clusters, and the importance firms attach to each cluster is influenced by the context (type of R&D, industry belonging, size) in which measurement takes place. Moreover, a firm's choice to measure R&D performance along a particular perspective (i.e., financial, customer, business processes, or innovation and learning) is influenced by the classes of objectives (diagnostic, motivational, or interactive) that are given higher priority.

Lazzarotti *et al.* (2011) proposed a formal model for measuring R&D performance based upon an adaptation of the original BSC framework. Accordingly, they defined a set of quantitative indicators concerning five performance perspectives, as follows: (i) financial; (ii) customer; (iii) innovation and learning; (iv) internal business processes; and (v) alliances and networks. The model was built consistently with the theory of measurement in soft systems. As stated in their work, this approach gave relevant guidelines for ensuring the model's validity, objectivity, and inter-subjectivity. Additionally, an application in a real R&D setting was described, which helps managers and academicians to understand the model and enlighten its main benefits and limits.

Bican and Brem (2020) analyzed the performance measures focusing on the level of R&D activities within the R&D department only. Through a mixed-method, grounded in prior literature of innovation and R&D measurement and evaluation systems, combined with text analysis, 154 R&D performance measures were developed and further condensed to 81 performance measures. These measures form a unique base to stimulate future research in performance measures and innovation network performance effects. Additionally, through a descriptive online expert survey and three independent focus group workshops with more than 40 industry experts from more than ten industries, the authors could select the most relevant key measures. These findings will be considered in the empirical phase of this research.

The study of Dewangan and Godse (2014) revealed some gaps in current innovation performance measurement (IPM) models, which lead to difficulties for organizations wanting to measure and evaluate their innovation performance. From the analysis of these gaps, the authors established a set of guiding principles for designing an IPM model, which addresses these obstacles and simplifies measuring and evaluating innovation performance. The authors argue that the PIM models must be multidimensional, process-based, stakeholders' goal-oriented, following a cause-effect relationship between measures, and easy to implement and use. They have demonstrated these principles' applicability in designing an IPM model through a case study within a bank. From the results of this empirical study, they concluded that the conceptual IPM model could be implemented in any organization to measure and evaluate their innovation performance effectively. Due to its importance for the modeling phase of the present research, the guiding principles for designing a model from a strategic and systemic perspective, as Dewangan and Godse (2014) proposed, are presented and discussed in the next section.

2.3. Guiding principles for designing a model from a strategic and systemic perspective

Dewangan and Godse (2014) have defined a set of guiding principles around which an effective innovation performance measurement model may be designed. This section enlists these principles and discusses how each of these was derived. These principles are:

- A multidimensional view should be provided by the performance measurement model;
- The model should be innovation process-oriented, focusing on measuring the performance of various stages within the innovation lifecycle;
- The model should effectively address stakeholders' organizational goals to both internal and external stakeholders;
- The model should support cause-and-effect relationships among the performance measures;
- The model should be easy to implement and use.

2.3.1.
Multidimensional orientation

A model designed for measuring and evaluating organizations' innovation capacity and performance should have a multidimensional orientation for effectively accommodating a well-balanced combination of financial and non-financial measures. In this context, several researchers agree that the balanced scorecard provides a good foundation for designing an innovation capacity and performance model, as noted in section 2.1. Leading and lagging indicators should be considered aiming to account for past, present, and probably future performance. The balanced scorecard takes care of past performance by including a financial perspective and future one, thus covering 'Customer', 'Internal Processes', and 'Learning and Growth' perspectives (Bremser and Barsky, 2004; Kaplan and Norton, 1996; 2006).

The balanced scorecard approach has been found to be useful for measuring innovation capacity and performance by several researchers once these two fundamental aspects have been confirmed in practice. For the purpose of the present research, a balanced scorecard is the methodological approach of choice. Given this backdrop, the balanced scorecard approach will be discussed further in Section 2.3.

2.3.2.
Innovation process orientation

Dewangan and Godse (2014) argue that a rigorous focus on process performance is an essential consideration for process-oriented organizations nowadays, as they are focused on continuous improvement.

It may be worth mentioning here that the focus of internal processes in the balanced scorecard is limited to those that affect either the customer value proposition or efficiency improvements leading to financial benefits (Kaplan and Norton, 1996; 2006). However, in the case of innovation management, to take an example, a process concerned with ideation may need a stronger focus on creating a unique or well-differentiated offering compared to predominantly financial considerations.

Most of the previous works based entirely upon the balanced scorecard do not adequately fulfill this guiding principle, despite there being instances of performance measurement for R&D (e.g., Brown and Svenson, 1988) and new product development (e.g., Suomala, 2004), which advocate a process or lifecycle-based innovation performance measurement. The process performance aspect of innovation will be explored in more detail in the modeling phase of this research.

2.3.3. Stakeholder’s goals orientation

An innovation capacity and performance measurement model should effectively address the achievement of the organization's strategic vision (Franco-Santos *et al.*, 2007), aligned to multiple stakeholders' interests like shareholders, employees, customers, suppliers, regulators, and society (Bourne *et al.*, 2003).

To deal with stakeholder's alignment, Clarkson (1995) defines corporate stakeholders as persons or groups who have, or claim, ownership rights or interests in a corporation and its activities, past, present, or future. Kaplan and Norton (1996; 2006) posit that the balanced scorecard, when used along with 'strategy maps', can effectively address stakeholders' needs. To illustrate: shareholders' needs can be addressed through financial perspective metrics, customers’ through customer perspective metrics, and employees' through growth and learning perspective metrics. Primary stakeholders are the participants without whom the enterprise cannot survive (Clarkson, 1995).

The innovation measurement model should offer an increased opportunity to address diverse stakeholder groups. For example, the idea management stage may involve innovation enthusiasts and intellectual property experts, incubation may encompass special interest groups, and commercialization may include downstream partners and innovation evangelists and secondary stakeholders like the media. The key indicators can be determined so that they are aligned to these goals once the stakeholders involved in each stage of the innovation process and their corresponding goals can be identified.

2.3.4. Cause-and-effect relationship orientation

The model should consider cause-and-effect relationships among the key innovation indicators so that they are logically related to one another (Bremser and Barsky, 2004; Gama *et al.*, 2007; Kaplan and Norton, 2006; Sandt *et al.*, 2001; Wong, 2001).

In fact, the cause-and-effect relationship orientation enables organizations to determine the value of various activities performed by relating them to definite results. The cause and effect relationship among the balanced scorecard perspectives for an organization can be effectively represented by creating its own ‘strategy map’, which is a generic business model representing the organization’s strategy showing linkages between specific elements within the BSC perspectives (Bremser and Barsky, 2004; Bukh and Malmi, 2005; Bremser and Barsky, 2004; Gama *et al.*, 2007; Kaplan and Norton, 2006; Sandt *et al.*, 2001; Wong, 2001).

For creating a strategic map, an organization will need to define the relevant elements to its business within each perspective. Some examples of these elements of perspective are: revenue growth and profits for the financial one, price and satisfaction for the customer’s, operational efficiency and customer delivery processes for the internal business, and employee competencies and asset knowledge base for the innovation and learning perspective. Each organization will have its own contextual relationship among the balanced scorecard dimensions, its own unique elements, and vision and, therefore, a unique ‘strategy map’.

2.3.5
Easy to implement and use

In this regard, a model based on the balanced scorecard framework provides a notable advantage since organizations already using it will find it easier to correlate innovation key indicators with their organizational key performance indicators. Besides, cascading of strategic goals can be supported by the balanced scorecard framework (Bremser and Barsky, 2004; Kaplan and Norton, 1996).

According to Dewangan and Godse (2014), it is assumed that a balanced scorecard can be defined at the organization level based on the vision and strategy, and relevant strategic goals can be cascaded down. For the purpose of this research, the strategic innovation goals should be derived from the organizational objectives across the balanced scorecard perspectives of sustainability, market, internal process, and learning and growth (as further described in Chapter 3).

2.4. The scorecard approach for measuring and evaluating innovation management: from principles to action

Balanced Scorecard (BSC) has been used by organizations for monitoring and evaluating their performance strategically. It is a methodological approach to determine business performance through lead and lag indicators aligned to their vision, mission, and values statements. This approach is based on the assumption that business performance should be evaluated considering both financial and non-financial indicators (Kaplan e Norton, 1996).

To measure the innovation and R&D performance at the organization level, BSC can definitely be considered a helpful tool, but only if there is a reasonable attempt to adapt the original framework. The required methodological adjustments refer mainly to the insertion of strategic innovation objectives, indicators, and metrics in each of the BSC perspectives (Gama *et al.*, 2007; Spanó *et al.*, 2016).

2.4.1. Balanced Scorecard (BSC) strategic management model: fundamentals and concepts

As organizations invest in acquiring these new capabilities, their success (or failure) cannot be motivated or measured by the traditional financial accounting model in the short term. The Balanced Scorecard model complements financial measures of past performance models with measures of the drivers of future ones. The objectives and measures of the scorecard are derived from an organization's vision and strategy. In addition, they view the organizational performance from four perspectives: 'Financial'. 'Customers', 'Internal processes', and 'Learning and growth'. These four perspectives provide the framework for the Balanced Scorecard strategic management model shown in Figure 2.1 (Kaplan e Norton, 1996).

Financial performance measures indicate whether an organization's strategy, implementation, and execution are contributing to bottom-line improvement, in the 'Financial' perspective of the BSC framework. Financial objectives typically relate to measured profitability, for example, by operating income, return on capital employed, or, more recently, economic value added.

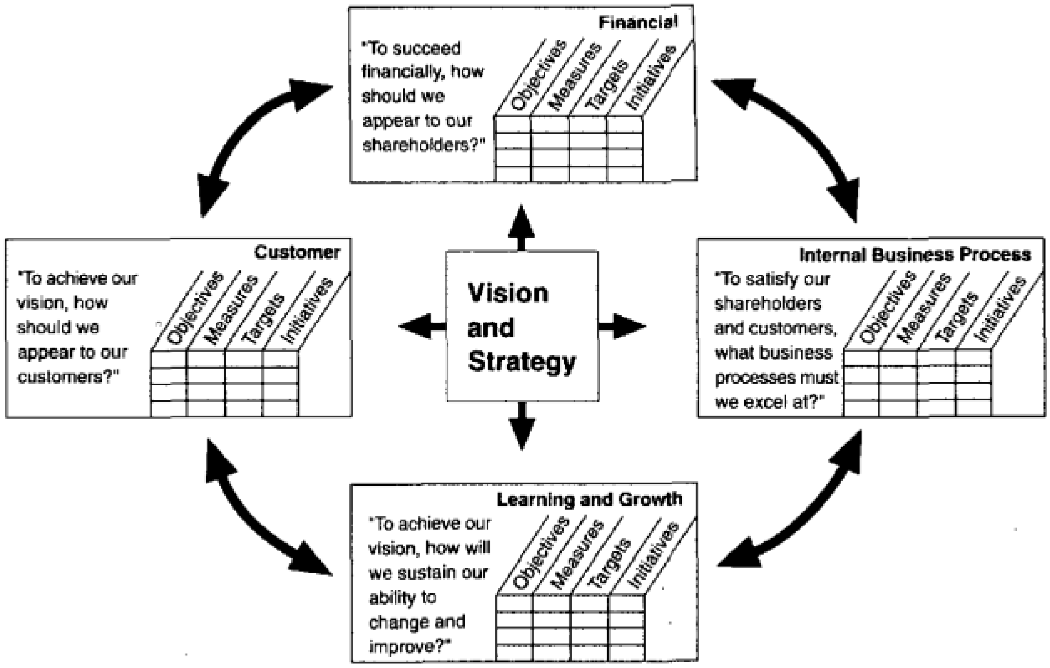

Figure 2.1 – Graphical representation of the Balance Scorecard (BSC) model.
Source: Kaplan and Norton (1996, p.9).

In the ‘Customer’s perspective, the focus is on the customer and market segments over which the organization will compete and measure its performance in these targeted segments. This perspective typically includes several core or generic measures of the successful outcomes from a well-formulated and implemented strategy. The core outcome measures include Customer's: satisfaction, retention, new acquisition, profitability, and market and account share in targeted segments. However, the Customer's perspective should also include specific measures of the value propositions which the company will deliver to them in targeted market segments.

In the internal business process perspective, managers identify the critical internal processes in which the organization must excel. These processes enable to deliver of the value propositions which will attract and retain customers in targeted market segments and satisfy shareholder's expectations of excellent financial returns. The internal business process measures focus on the internal processes, which will have the greatest impact on Customer's satisfaction and achieving an organization's financial objectives. That perspective reveals two fundamental differences between the traditional and the BSC approaches to performance measurement. The first attempts to monitor and improve existing business processes, going beyond financial measures of performance by incorporating quality and time-based metrics. Nevertheless, they still focus on the improvement of existing processes. However, the scorecard approach will usually identify entirely new processes at which an organization must excel to meet Customer's and financial objectives.

The second differential of the BSC approach is to incorporate the innovation process into the internal business process perspective (Figure 2.2).

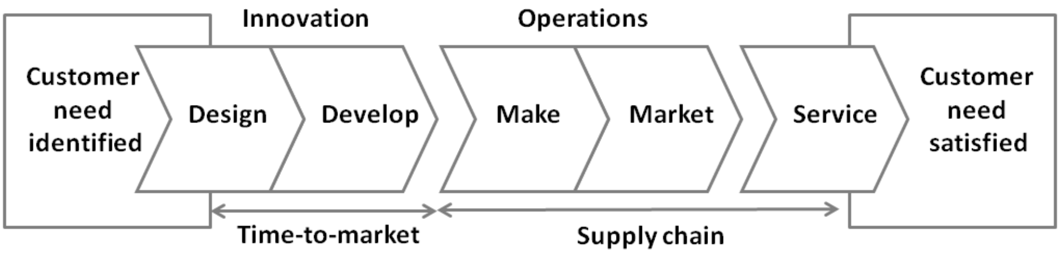

Figure 2.2 – The internal- business- process value-chain perspective
Source: Kaplan and Norton (1996, p.27).

Traditional performance measurement systems focus on the processes of delivering today's products and services to today's customers. They attempt to control and improve existing operations, which represent the short wave of value creation. This begins with the receipt of an order from an existing customer for an existing product (or service).

The fourth perspective of the BSC framework, 'Learning and growth', identifies the infrastructure which the organization must build to create long-term growth and improvement. The ‘Customer's’ and ‘Internal business process’ perspectives identify the most critical factors for current and future success. Businesses are unlikely to be able to meet their long-term targets for customers and internal processes using today's technologies and capabilities. Also, intense global competition requires that organizations continually improve their capabilities for delivering value to customers and shareholders. Organizational learning and growth come from three principal sources: (i) people, (ii) systems, and (iii) organizational procedures. The ‘Financial’, ‘Customer's’, and ‘Internal-business-process’ strategic objectives on the Balanced Scorecard model typically will reveal large gaps among the existing capabilities of people, systems, and organizational procedures and what will be required to achieve breakthrough performance.

In summary, the Balanced Scorecard expands the set of business unit objectives beyond summary financial measures. This strategic management model captures the critical value creation activities caused by lulled, motivated organizational participants. While retaining, via the financial perspective, an interest in short-term performance, the Balanced Scorecard reveals the value drivers for superior long-term financial and competitive performance.

The Balanced Scorecard should translate a business unit mission and strategy into tangible objectives and measures. The measures represent a balance among external measures for shareholders and customers and internal measures of critical business processes, innovation, and learning and growth. These measures are balanced among the outcome ones-the results from past efforts-and the ones which drive future performance. Besides, the scorecard is balanced between strategic objectives, easily quantified outcome measures, and subjective, somewhat judgmental, performance drivers of the outcome measures. The Balanced Scorecard is more than a tactical or an operational measurement system. Innovative organizations have been using the scorecard as a strategic management system to direct their strategy over their long term (see Figure 2.2).

As posed by Kaplan and Norton (2006), innovative organizations have been employing the measurement focus of the scorecard to accomplish critical management processes, aiming at: (i) clarifying and translating future vision and strategy; (ii) communicating and linking strategic goals and key performance indicators; (iii) planning, setting targets, and aligning strategic initiatives; and (iv) enhancing strategic feedback and learning.

2.4.2. Adaptation of the BSC framework for measuring and evaluating innovation capacity and performance

As mentioned before, amongst the 28 empirical studies summarized in Table 2.2, 15 had employed the scorecard approach, adapting the original conceptual framework to include specific innovation strategic objectives and associated key indicators and metrics. One can distinguish two streams in these studies: the first focuses on innovation performance (Gama *et al.*, 2007; Spanó *et al.*, 2016; Ivanov and Avasilcai, 2014; Dewangan and Godse, 2014; Dudic *et al.*, 2020), while the second emphasizes the measurement and evaluation of R&D

outcome and processes (Bremser and Barsky, 2004; Ojanen and Vuola, 2006; Chiesa *et al.*, 2009; Lazzarotti *et al.*, 2011; and Bican and Brem, 2020).

As can be observed, considerable research has been devoted to models for measuring and evaluating R&D and innovation performance based on the BSC framework. Previous works have focused on adapting the original BSC model to measure R&D and innovation performances at the organization level. Innovation and R&D indicators associated with BSC perspectives have also been proposed in these works. However, integrating multicriteria decision-making approaches into BSC models designed for R&D and innovation management has remained unknown to researchers and managers. Mainly, concerning this issue, a research gap was identified to be explored in the modeling phase by integrating multicriteria decision-making methods into BSC models designed for strategic innovation management measurement.

2.4.3. Opportunity to integrate multicriteria decision-making methods into BSC models designed for strategic innovation management measurement

An important aspect of any multiple criteria decision scheme is that the appropriate weight must be placed on each measure or criterion. However, the BSC framework does not provide guidance as to how these weights should be computed. There are many ways or plans to distribute the reward. Some of these plans allow bonuses to be paid even when performance is ‘unbalanced’ (i.e., when there has been over-achievement in some areas but under-achievement in others). Other plans require a minimum level (hurdle) to be attained in each perspective before bonuses can be paid.

The relationships among the BSC perspectives also complicate the determination of the weight of the key indicators. The BSC framework acknowledges the presence of dynamic relationships among the perspectives, which means that the importance of one of them cannot be determined without knowing the effects of the relationships among them. It is important that the proper weights be determined for both innovation capacity and performance indicators to avoid situations in which a manager is inappropriately rewarded or penalized.

Following the taxonomy proposed by Vincke (1992), MCDM methods can be classified into three categories: (i) multi-attribute utility theory, (ii) overclassification methods, and (iii) interactive methods. In this research, the option was to select one or more methods framed in the first category due to the characteristics of the research problem, i.e., weighting key innovation indicators considering the cause-and-effect relationships among them. This category comes from the American School, considered a classic multicriteria approach, and includes the most well-known models reported in the literature, such as AHP, ANP, MAUT, PROMETHEE, DEMATEL, and TOPSIS. The Analytic Network Process (ANP) method's option was because it allows structuring the criteria and subcriteria in a network structure and analyzing the cause-effect relationships of cross-influences, among the elements that the other methods do not allow. The ANP also does not require that the problem has specific alternatives that need to be compared or classified.

When the decision making process involves attributes that have a dependency relationship, the problem should be modeled with the support of the Analytic Network Process (ANP) method (Saaty, 2005). In this research, the BSC problem is modeled as an ANP, as shown in Figure 3.1 (Chapter 3). A collection of similar attributes is referred to as a cluster, and the perspectives themselves form one. The attributes of each measure or sub-measure form one and there are K such clusters, including the ratings. The dependency relationship among the attributes within a cluster is called inner dependency, denoted by a directed loop for the cluster. A two-way dependency relationship among attributes in two different clusters is called interdependency, which is denoted by a two-way directed arc among the clusters.

2.5. Final remarks of this chapter

In this chapter, the BSC approach was examined within the context of innovation capacity and performance measurement and evaluation. From a broader perspective, the BSC has been viewed as a vehicle to articulate an organization's strategies, communicate these strategies to employees and stakeholders, and help align individual and organizational initiatives to realize its strategic goals.

Focusing more specifically on methodological issues, it can be concluded that among the 28 studies, 15 adopted the scorecard approach (Kerssens-van-Drongelen and Cook, 1997; Wong, 2001; Verhaeghe and Kfir, 2002; Godener and Soderquist, 2004; Bremser and Barsky, 2004; Ojanen and Vuola, 2006; Gama *et al.*, 2007; Chiesa and Frattini, 2009; Lazzarotti *et al.*, 2011, Mohamed, 2013; Dewangan and Godse, 2014; Spanò *et al.*, 2016; Zhang, 2016; Bican and Brem, 2020; and Dudic *et al.*, 2020).

As a matter of fact, the balanced scorecard approach differs from other approaches designed to measure organizations' performance because it considers cause-and-effect relationships between strategic goals, key indicators, targets, and aligns initiatives with the strategic vision of organizations. In the field of strategic innovation management, it is especially relevant due to the imperative of organizations to innovate systematically with a long-term vision, thus enabling the creation of a culture of innovation at all levels of the organization.

An in-depth analysis of these 15 studies reveals a research gap regarding the use of a multicriteria decision-making approach which implements a networked structure and allows analyzing cause-and-effect relationships and feedback among strategic goals and key innovation indicators. Notably, the assignment of weights to the key indicators which integrate the BSC framework analyzing the cause and effect relationships among the mentioned elements should be considered in the modeling phase of this research.

3
Conceptual model for measuring and evaluating innovation capacity and performance in organizations

This chapter introduces the conceptual model for measuring and evaluating innovation capacity and performance in established organizations, aligned with the guiding principles of multidimensional structure, innovation process orientation, stakeholder's goal orientation, cause-effect relationship analysis, and easy implementation and use. The Analytic Network Process (ANP) method (Saaty, 2004; 2005) was integrated into the conceptual model based on the BSC framework (Kaplan and Norton, 1996; 2006) for determining the importance weights of key innovations indicators associated with the strategic innovation goals of the organization.

In line with the methodology described in the introductory chapter and the literature review covered in Chapter 2, Figure 3.1 schematically represents the model comprising six stages, as follows:

- Determination of the network model based on the BSC framework;
- Design of a questionnaire for pairwise comparisons of the network elements and clusters;
- Pairwise comparisons for determining the importance weights of network elements and clusters;
- Calculation of the limit supermatrix and resulting weights of the network elements;
- Determination of five-point scales for measuring the innovation capacity (IC) and innovation performance (IP);
- Application of the self-assessment instrument and calculation of the IC and IP indexes.

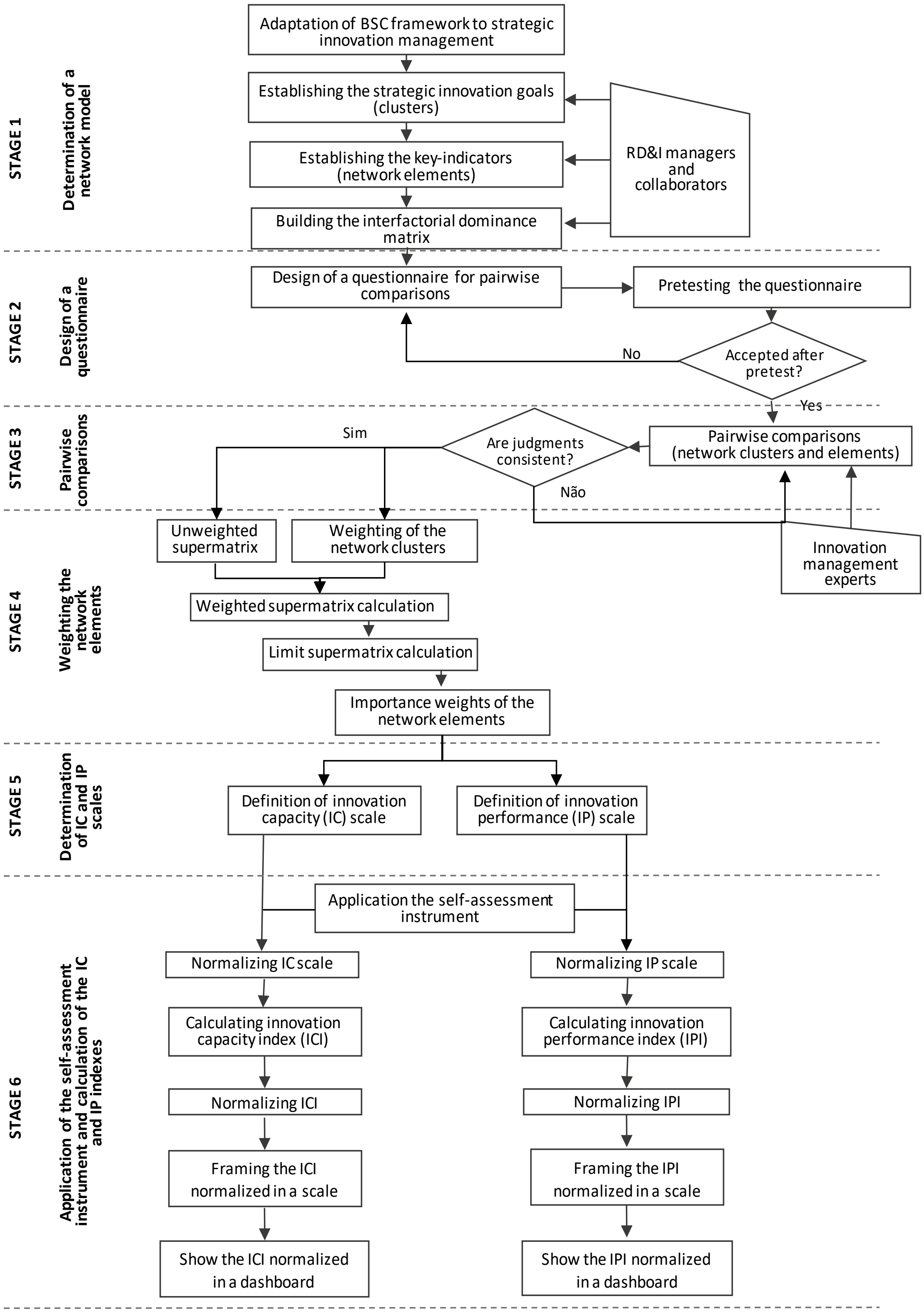

Figure 3.1 – General view of the conceptual model for measuring and evaluating innovation capacity and performance in organizations
Source: Author's elaboration.

3.1. Stage 1: Determination of the network model based on the BSC framework

Based on the BSC framework (Kaplan and Norton, 1996; 2006) and the principle of operability, the organizations' innovation capacity and performance can be measured and evaluated considering four assessment perspectives, namely, sustainability (B1), market (B2), internal process (B3), and learning and growth (B4). These perspectives were adapted from the original BSC perspectives (as shown before in Chapter 2 - Figure 2.1) to be applied in strategic innovation management processes at the organization level.

In addition, similarly to the BSC model proposed by Spanò et al. (2016), strategic innovation goals were associated with the four BSC perspectives, as shown in Figure 3.2. Top managers within the organization should establish the strategic innovation goals as part of the strategic planning, whose results can be schematically represented in a 'strategy map'. Based on the BSC methodological approach presented in Chapter 2 (Section 2.3), a schematic 'strategy map' based on the BSC framework and represented in Figure 3.2 highlights the cause-and-effect relationships among the strategic innovation goals (G11 to G13, G21, G31, G41, and G42).

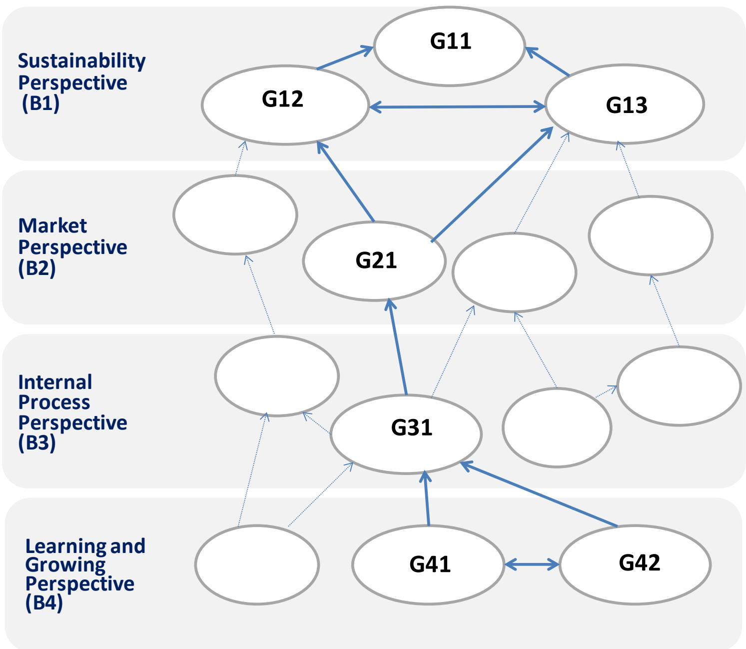

Figure 3.2 – Schematic representation of a 'strategy map' based on the BSC framework
Note: B1 to B4 – BSC perspectives; G11 to G42 - Strategic innovation goals.
Source: Author's elaboration.

After establishing the strategic innovation goals associated with the four BSC perspectives, RD&I managers and collaborators within the organization should define key innovation indicators to integrate the conceptual model to determine the network model based on the BSC framework. It is important to mention that key innovation indicators and metrics must be chosen by each organization and depend on its strategic innovation goals. Therefore, organizations should have a well-defined innovation strategy before selecting the key innovation indicators.

Accordingly, this set of key innovation indicators should be selected among various indicators reported in previous works (e.g., Gama *et al.*, 2007; Chiesa and Frattini, 2009; Lazzarotti *et al.*, 2011, Mohamed, 2013; Dewangan and Godse, 2014; Spanò *et al.*, 2016; Zhang, 2016; Bican and Brem, 2020; and Dudic *et al.*, 2020) and also in survey instruments adopted by regional and national initiatives to measure innovation capacity and performance of companies. Examples of these initiatives are the Community Innovation Survey (CIS) in Europe and the National Innovation Survey (Pintec) in Brazil. This step can be conducted in light of criteria usually adopted in the monitoring and evaluation field (USAID, 2010; Görgens and Kusek, 2009; Kusek and Rist, 2004).

A set of innovation indicators presented in appendix 1 results from a literature review conducted in the exploratory phase of this research and should be used during the empirical study to be developed in a company in the Brazilian electric sector (Chapter 4). Table 3.1 shows a generic analytical structure since the ultimate one must be defined by RD&I managers and collaborators involved in this process within the organization under evaluation.

Table 3.1 - Generic analytical network structure based on the BSC framework

Target layer	Control layer		Innovation indicator layer
	BSC perspective	**Strategic innovation goal**	
Measurement and evaluation of the innovation performance (IP)	Sustainability [B1]	G11	I 111 to I 11n
		G12	I 121 to I 12n
		G13	I 131 to I 13n
		G1n	I1n1 to I1nn
	Market [B2]	G21	I 211 to I 21n
		G2n	I2n1 to I2nn
Measurement and evaluation of innovation capacity (IC)	Internal process [B3]	G31	I 311 to I 31n
		G3n	I3n1 to I3Nn
	Learning and growth [B4]	G41	I 411 to I 41N
		G42	I 421 to I 42n
		G4n	I 4n1 to I4Nn

After selecting the key indicators, a network model based on the analytic structure shown in Table 3.1 should be determined, comprising the control and network layers.

In Figure 3.2, the total of seven strategic innovation goals (G11 to G13, G21, G31, G41, and G42) is a mere suggestion. In practice, in the analytical network structure, the number of strategic innovation goals (G11 to GNn) should correspond to those that integrate the organization's strategy map. Therefore, they also must be defined by top managers within the organization. It is essential to mention that each corporate 'strategy map', including the strategic innovation goals and others, is unique for each organization.

The first layer consists of strategic innovation goals (G11 to GNn), and the latter is composed of 'n' key innovation indicators, organized in clusters, as shown in Figure 3.3.

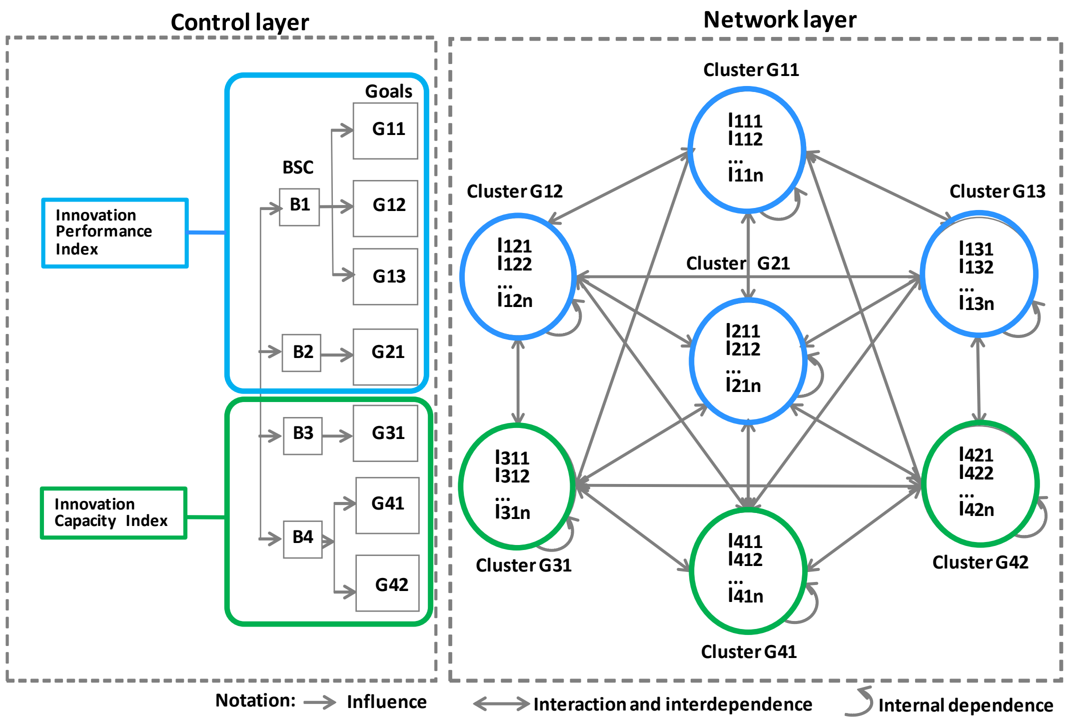

Figure 3.3 The BSC-ANP model for measuring and evaluating the organizations' innovation capacity and performance

Note: The number of strategic innovation goals here is a mere suggestion, consistently with Figure 3.2.

Source: Author's elaboration.

Subsequently, to determine the influences among the key innovation indicators, a zero-one interfactorial dominance matrix is built, whose elements take the value 1 or 0 depending on whether there is or there is not some influence of one element on another one. The matrix's rows and columns are formed by ‘n’ key innovation indicators grouped into clusters, corresponding to the set of strategic innovation goals.

Before going any further, it is essential to emphasize that the four BSC perspectives are equally important in this conceptual model, from the perspective of measuring and evaluating the organization's innovation capacity and performance. Thus, in this network model, the pairwise comparisons will be restricted to the strategic innovation goals (clusters) and respective innovation indicators (assessment factors).

3.2.
Stage 2: Design of a questionnaire for pairwise comparisons of the network elements and clusters

The design of a questionnaire for pairwise comparisons should consider the key innovation indicators and the strategic innovation goals that integrate the BSC-ANP model and Saaty’s nine-point scale (Table 3.2).

In this stage, a pretesting of the questionnaire must be undertaken to evaluate its clarity, suitability to the respondents, the required time to answer the questions, and also the possible obstacles that could arise during its application. In its final version, the questionnaire must contain objective instructions for proper completion. The judgments in the paired comparisons consist of answering two questions: (i) which of the two elements is the most important concerning the desired objective and with what intensity. For this, the nine-point scale proposed by Saaty (1980; 1990) must be adopted, as shown in Table 3.2 below.

Table 3.2 – Saaty’s nine-point scale for paired comparisons

Level of importance	Definition
1	Same importance
2	Preference between the same and moderate
3	Moderate preference
4	Preference between moderate and strong
5	Strong preference
6	Preference between strong and very strong
7	Very strong preference
8	Preference between very strong and absolute
9	Absolute preference

Source: Saaty (1980; 1990).

After being validated, the questionnaire is ready to be applied to managers and collaborators engaged in RD&I activities within the organization in focus. If there are a number of experts involved in this evaluation, consensus can be achieved in a consensus-building meeting (Saaty, 1980; 1990) or by employing fuzzy logic to compute the collective weightings (Zadeh, 1965).

3.3. Stage 3: Pairwise comparisons for determining the importance weights of network elements and clusters

In this stage, Saaty's nine-point scale (Table 3.2) should be used for the pairwise comparisons on the elements conducted by RD&I managers and collaborators involved with the innovation measurement process within the organization.

When adopting the ANP method (Saaty, 2004; 2005), the managers or panel experts who make judgments or preferences must go through the consistency test conducted based on the consistency ratios (C.R.) of the pairwise comparison matrixes. This is the ratio of its consistency index to the corresponding random value. The details can be found in Saaty (1980; 1990). The corresponding pairwise comparison matrices are generated in order to obtain the corresponding eigenvectors (unweighted supermatrix).

The value corresponding to the priority associated with a specific cluster determines the importance of its elements on which it acts (in the unweighted supermatrix). Thus the weighted supermatrix can be generated. So, the weighted supermatrix comes from combining the unweighted supermatrix and the control hierarchy matrix (i.e., pairwise comparison of the strategic innovation goals). The latter scores a cluster weight in comparison to all others to which it is connected. An n*n matrix should be built, where 'n' is the number of network clusters. To establish the control hierarchy matrix, first of all, a cluster Ci is chosen. Then, all others connected with Ci are pairwise compared (with the AHP method) to determine their impact on Ci. In this way, a weighted supermatrix can be obtained. Afterward, the matrix will be limited, and gradually the consolidation of the interdependency and relative weights will be derived (Saaty, 2004; 2005). Accordingly, a weighted supermatrix can be obtained.

The weights of the selected key innovation indicators can be calculated with support of the Super Decisions® software (Creative Decision Foundation, 2019), following these two last steps, as follows:

(i) Use of design-cluster-new order to set up clusters;
(ii) Use of design-node-new order to set up element nodes;
(iii) Use of do-connections-order to set up the internal connections (internal dependency) within the same cluster as well as connections (external dependency) among different clusters;
(iv) Use of assess/compare-pairwise comparison order to compare the relations between clusters and element nodes according to Saaty's nine-point scale (table 3.2), and to generate a comparison matrix;
(v) Use of computations-unweighted supermatrix order to calculate the unweighted supermatrix of the ANP model, aligned to the comparison matrix;
(vi) Use of computations-weighted supermatrix order to calculate the weighted supermatrix, which represents the degree of the global dominance of the corresponding element nodes, and the sum of elements in columns is 1.

3.4.
Stage 4: Calculation of the limit supermatrix and resulting weights of the network elements

With the support of Super Decisions® software (Creative Decision Foundation, 2019), a computations-limit matrix can be used to calculate the limit supermatrix, which is derived from doing power operation on the weighted supermatrix, and its weighted value tends towards stability. Gradually the consolidation of the interdependency and relative importance weights will be obtained.

3.5.
Stage 5: Determination of five-point scales for measuring the innovation capacity (IC) and innovation performance (IP)

The objective of this stage is to propose two five-point scales based on the common characteristics of previous works (Weerawardena, 2003; Alegre *et al.*, 2006; Calik *et al.*, 2017). Weerawardena (2003) examined the role of marketing capabilities in competitive innovation-based strategy. The research helps to refine and validate measures of entrepreneurship, marketing skills, organizational innovation, and sustained competitive advantage. Alegre et al. (2006), in turn, proposed scales for valid measures concerning two key dimensions of performance - effectiveness, and efficiency of product innovation. Calik et al. (2017) developed a scale for innovation capability measurement, based on the results of a survey conducted with enterprises in Turkey.

As can be observed in Tables 3.3 and 3.4, both scales range from level 5 (high innovation capacity or performance) to level 1 (low innovation capacity or performance). The two scales should be adopted during the self-assessment conducted by RD&I managers and experts within the organization, whose innovation capacity and performance are being measured and evaluated (see Section 3.6).

Table 3.3 - Five-point scale for measuring innovation capacity (IC) at the organization level

Innovation capacity level	**Description**
1. Low innovation capacity	Low degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Internal Processes’ and ‘Learning and Growth’ BSC Perspectives
2. Low-medium innovation capacity	Low-medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Internal Processes’ and ‘Learning and Growth’ BSC Perspectives
3. Medium level innovation capacity	Medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Internal Processes’ and ‘Learning and Growth’ BSC Perspectives
4. Medium-high innovation capacity	Medium-high degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Internal Processes’ and ‘Learning and Growth’ BSC Perspectives
5. High-level innovation capacity	High degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Internal Processes’ and ‘Learning and Growth’ BSC Perspectives

Source: Author’s elaboration.

Table 3.4 - Five-point scale for measuring innovation performance (IP) at the organization level

Innovation performance level	**Description**
1. Low innovation performance	Low degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Market’ and ‘Sustainability’ BSC Perspectives
2. Low-medium innovation performance	Low-medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Market’ and ‘Sustainability’ BSC Perspectives
3. Medium level innovation performance	Medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Market’ and ‘Sustainability’ BSC Perspectives
4. Medium-high innovation performance	Medium-high degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Market’ and ‘Sustainability’ BSC Perspectives
5. High-level innovation performance	High degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from ‘Market’ and ‘Sustainability’ BSC Perspectives

Source: Author’s elaboration.

3.6. Stage 6: Application of the self-assessment instrument and calculation of the IC and IP indexes

In this stage, the design of the self-assessment instrument should take into account the network elements, i.e., the ‘n’ clusters (strategic innovation goals), the ‘n’ key innovation indicators associated with them, and the five-point scales proposed in stage 2 of the model (Tables 3.3 and 3.4). As performed in the case of the first questionnaire designed for pairwise comparisons, a pretesting must be undertaken in this stage to evaluate the instrument's clarity, suitability to the respondents, and the required time to answer the questions.

After being validated, the self-assessment instrument is ready to be applied to managers and collaborators engaged in RD&I activities within the organization in focus. Considering that complexity, multidimensionality and uncertainty are characteristics inherent to innovation capacity and performance measurement, fuzzy logic (Zadeh, 1965) is strongly recommended in this stage since various managers and collaborators will undoubtedly be involved.

The next step in this stage is to calculate the Innovation Capacity (ICI) and Innovation Performance (IPI) indexes. For this, managers and experts engaged in RD&I activities within the organization are asked to quantify innovation capacity concerning the key innovation indicators associated with the lower BSC perspectives (‘Internal Process’ and ‘Learning and Growth’).

Using the five-point scale shown in Table 3.3, the Innovation Capacity (IC) Index of the organization is calculated by multiplying the ratings assigned by the managers and experts with the relative weights of those key innovation indicators. Hence, the innovation capacity can be calculated by multiplying the ratings assigned by the managers and experts with the relative weights of key innovation indicators associated with the lower BSC perspectives (‘Internal Process’ and ‘Learning and Growth’). The resulting IC Index can be calculated by summing them up.

Similarly, the Innovation Performance (IP) Index can also be calculated, but in this case, the relative weights of key innovation indicators will be those of the upper BSC perspectives (‘Market’ and ‘Sustainability’) and the five-point scale to be adopted is presented in Table 3.4.

3.7. Discussion of results

The conceptual model presented in this chapter is aligned with the guiding principles recommended by Dewangan and Godse (2014) for designing a model for measuring and evaluating the innovation capacity and performance in organizations from a strategic and systemic perspective (see Section 2.2). It may contribute to the improvement of innovation performance measurement practices that have been conducted by established organizations aiming to achieve excellence in managing their RD&I processes. These contributions refer mainly to the use of a multicriteria decision-making approach integrated into an adapted BSC framework, especially addressed to answer the research questions posed in the introductory section. Besides, the use of the Super Decisions (SD) software lays the foundation for the wide-ranging use of the ANP model and could simplify the focused organizational process. The overall weight of the set of 'n' key innovation indicators can be calculated by using the SuperDecisions® software (Creative Decision Foundation, 2019).

In this chapter, an attempt was made to propose a conceptual model designed to measure and evaluate the organizations' innovation capacity and performance by integrating a multicriteria decision-making approach to the BSC framework. These results refer to several specific objectives of this research and establish a basis for a more complex future work since the conceptual model here proposed is part of an ongoing research line in the Technology and Innovation Management (TIM) field within the Programa de Pós-graduação em Metrologia da PUC-Rio. The next chapter focuses on an empirical study developed within an innovative company of the Brazilian electricity sector to demonstrate the applicability of the proposed conceptual BSC-ANP model.

4
Applicability of the BSC-ANP model: an empirical study in an innovative company in the Brazilian electric sector

The results of an empirical study developed within an innovative company in the Brazilian electric sector are reported and discussed, aiming to demonstrate the applicability of the proposed BSC-ANP model in a corporate environment. As a result, the actual Innovation Capacity (IC) and Innovation Performance (IP) Indexes could be calculated from the ratings assigned to the achievement level of RD&I initiatives associated with 23 key innovation indicators that are part of the company's 'strategy map'. At the end of the chapter, managerial and policy implications are discussed, particularly the research contributions addressed to answer two questions posed in the ANEEL Public Consultation n. 017/2019 concerning the revision of criteria for assessing innovation capacity and performance of companies in the electricity sector.

4.1. Empirical study proposition and guiding questions

The purpose of this empirical study is to demonstrate that the BSC-ANP model proposed in this dissertation can be used effectively to measure and evaluate the innovation capacity and performance of organizations that seek excellence in their innovation management systems to achieve higher levels of innovation performance. It is intended to empirically validate the conceptual BSC-ANP model in an innovative company in the Brazilian electric sector, whose fictitious name is Companhia Alfa.

Following the protocol suggested by Yin (2005), five guiding questions were defined:

- Is it feasible to demonstrate the BSC-ANP model's applicability through an empirical study conducted at Companhia Alfa, with the participation of the Innovation Manager, Technical Assistant and collaborators working in the Innovation Area of this company?

- What does the 'strategy map' of Companhia Alfa look like, and what key innovation indicators were chosen to integrate the network layer of the BSC-ANP model?
- What are the company's innovation capacity and performance indexes?
- What recommendations should be sent to the company's top leadership to enhance corporate impacts from the value generated by successful RD&I initiatives?
- From the results presented here and in Chapter 3, what subsidies may be addressed to ANEEL for the revision of the regulatory framework of the ANEEL R&D Program, focusing on the item "Criteria for assessing innovation in companies in the electric sector", according to the ANEEL Public Consultation n. 017/2019?

The results of each of the stages of the empirical study developed within the Companhia Alfa are presented below.

4.2. Characterization of the unit of analysis and its organizational and business contexts

The unit of analysis of this empirical study and the organizational context of Companhia Alfa are characterized in the next items.

4.2.1. Unit of analysis

According to Yin (2005), the unit of analysis needs to reflect the way in which the research problem was defined. Thus, focusing on the central research problem, the unit of analysis in this empirical study was defined as the innovation capacity and performance measurement and evaluation, based on the BSC-ANP model presented in Chapter 3.

4.2.2. Organizational and business context

Companhia Alfa is a thermal power generator with a large capacity contracted in the country. It was founded in 2001, and in 2007 it won its first energy auction and currently has activities in five states in Brazil. Table 4.1 summarizes the corporate profile of Companhia Alfa.

Table 4.1 – Summary of the Companhia Alfa corporate profile

Company name: Companhia Alfa (fictitious name)*
Operating sector (CNAE / IBGE Classification - 4 digits): 3511-5 / 01 - Electricity generation.
Foundation year: 2001
Primary address and telephone number (s): Rio de Janeiro
Number of employees: More than 1000
Origin of controlling capital: National
What are the main challenges that the company faces to innovate? • To achieve dedication of key internal resources, which end up having to deviate from their main duties. • To demonstrate financial returns from the beginning, when the RD&I stages are still highly uncertain.
Does the company have a strategic innovation management system? What management tools does the company employ? Yes. We have a dedicated Innovation Area at the holding company, which is responsible for centrally investing in innovation initiatives. The main tools are the usual collaboration and project management (e.g.,. MS Teams, file sharing), business integrated management system (e.g., SAP), and RD&I performance analysis (using, for instance, Excel)
Participants: Innovation Manager and Technical Assistant: Stage 1 (network model based on the BSC framework) and Stage 6 (self-assessment of Companhia Alfa regarding its innovation capacity and performance. Collaborators working in the Innovation Area: Stage 3 (pairwise comparisons of network elements and clusters).

Source: Author's elaboration, based on information gathered from Companhia Alfa.

Note: (*) This fictitious name is used because the Innovation Manager agreed to participate in this empirical study, as long as its identity was not revealed. The reason is that the information provided refers to a strategic area of the company, and a complete profile could reveal the company's identity.

With respect to its CNAE, the holding has a different classification from the generation subsidiaries. Therefore, as this empirical study took place within the context of the Brazilian electricity sector, it was decided to disregard the holding Company's CNAE and consider the subsidiaries' CNAE.

One reason to choose this company for applying the BSC-ANP conceptual model is that it stated in its strategic vision that the organization intends to be recognized for its innovation capacity and performance. Another important aspect of the company is its sustainability policies that provide subsidies for research, reinforcing its commitment to monitor its economic, environmental, and social impacts.

The company's participants in this empirical study believe that the conceptual model here proposed brings a methodological solution for the complex problem of measuring and evaluating innovation capacity and performance at the organization level.

4.3. Demonstrating the applicability of the BSC-ANP model

The application of the BSC-ANP model at Companhia Alfa followed rigorously all steps described in Chapter 3, as shown in Table 4.2.

Table 4.2 – Overview of the empirical study conducted in Companhia Alfa

Stage	Description in Chapter 3	Participants
Stage 1 - Determination of the network model based on the BSC framework.	Section 3.1	Innovation Manager and Technical Assistant of Companhia Alfa. Author and his advisor.
Stage 2 - Design of a questionnaire for pairwise comparisons of the network elements and clusters.	Section 3.2	Questionnaire design: author. Pretesting: a small group of MSc. students attending the 'Multicriteria Course' in PósMQI/PUC-Rio.
Stage 3 - Pairwise comparisons for determining the importance weights of network elements and clusters.	Section 3.3	Pairwise comparisons: three collaborators working in the Innovation Area of Companhia Alfa.
Stage 4 - Calculation of the limit supermatrix and resulting weights of the network elements.	Section 3.4	Author, with support of THE Super Decisions® software
Stage 5 - Determination of five-point scales for measuring the innovation capacity (IC) and innovation performance (IP).	Section 3.5	Author, based on the literature review.
Stage 6 - Application of the self-assessment instrument; and calculation of the IC and IP indexes.	Section 3.6	Self-assessment: Innovation Manager and Technical Assistant of Companhia Alfa. Calculation of the IC and IP indexes: author.

Source: Author's elaboration.

4.3.1. Stage 1: Determination of the network model based on the BSC framework

As described in Section 3.1 (Chapter 3), the four original BSC perspectives were adapted to be applied in the context of the innovation management system in organizations in general, and in particular within the Companhia Alfa. During the first interview with its Innovation Manager, it was found that the company had already established strategic innovation goals as part of its strategic planning. However, the company has not adopted the BSC approach yet.

Following, the author and his advisor proposed a virtual kickoff meeting with the Innovation Manager and his Assistant to explain the objectives and the BSC-ANP model, and classify the company's strategic innovation goals in a 'strategy map' based on the BSC framework.

The results of this first meeting are schematically represented in Figure 4.1.

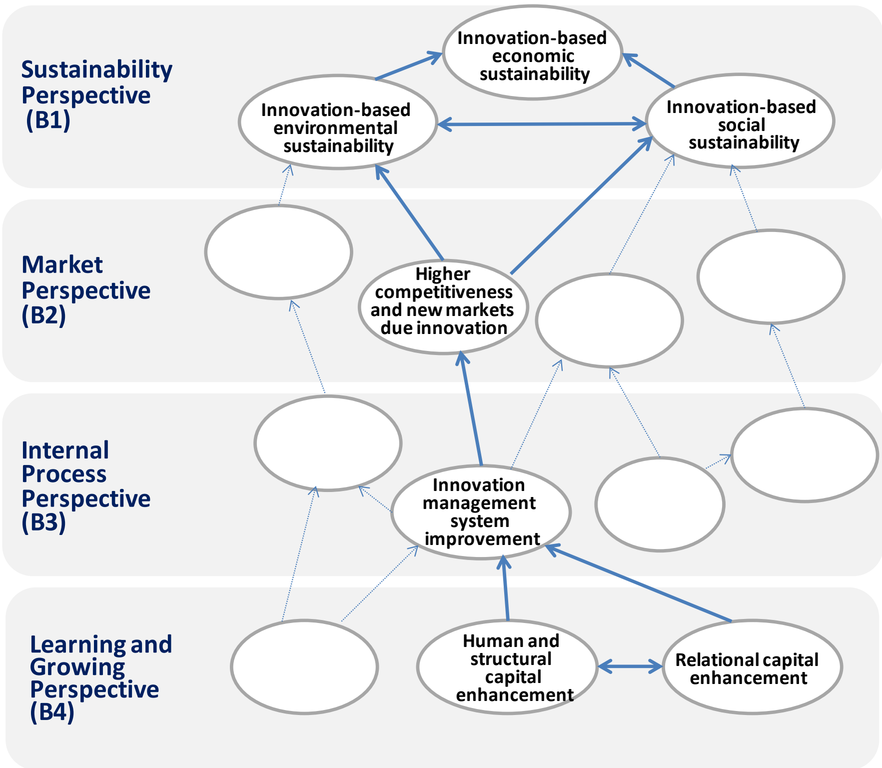

Figure 4.1 – Schematic representation of the 'strategy map' of Companhia Alfa

After classifying the strategic innovation goals according to the four BSC perspectives, the Innovation Manager and Technical Assistant were asked to define the set of key innovation indicators related to the seven innovation goals in a second virtual session. This information was crucial to integrate the network model based on the BSC framework.

Previously to this meeting, the author had sent a list of key innovation indicators identified in the literature review and some survey instruments adopted by regional and national initiatives to measure innovation capacity and performance of companies, as mentioned in Chapter 3. This initial list is presented in appendix 1. During this second meeting, a set of 23 key innovation indicators were selected and classified accordingly.

Table 4.3 shows the analytical structure based on the BSC framework jointly defined with the Innovation Manager and one collaborator from the Innovation Management Department who participated in this empirical study.

Table 4.3 – Analytical structure based on the BSC-ANP model for Companhia Alfa

Target layer (A)	Control layer		Innovation indicator layer
	BSC perspective	Strategic innovation goal	
Measurement and evaluation of the innovation capacity (IC)	Sustainability [B1]	Innovation-based economic sustainability [G11]	I111 - Royalties of commercialized patents per year
			I112 - Net cash generated by commercialized patents and products per year
		Innovation-based environmental sustainability [G12]	I121 - GHG emissions reduction due to innovation
			I122 - Improvement in the use of renewable energies and energy efficiency due to innovation
			I123 - Number of innovative solutions to mitigate risk (operational risk, compliance risk, environmental risk)
			I124 - Number of innovative waste management solutions
		Innovation-based social sustainability [G13]	I131 - Involvement with local SMEs in supply chain management
			I132 - Startups birth rate
			I133 - Number of innovations with social impacts
	Market [B2]	Higher competitiveness due to innovation [G21]	I211 - Number of new or significantly improved products introduced onto the market
			I212 - Number of firms adopting the commercialized patents and products
			I213 - Market share of firms adopting the commercialized patents and products
Measurement and evaluation of the innovation performance (IP)	Internal processes [B3]	Innovation management system improvement [G31]	I311 - % of projects that developed new models, methods and/or standards to improve RD&I practices per year
			I312 - Number of new business models or innovative solutions implemented through collaborative projects per year
			I313 - Planning accuracy in innovation management, i.e., % of agreed milestones and/or objectives achieved
	Learning and Growth [B4]	Human and structural capital enhancement [G41]	I411 - Number of employees devoted to RD&I activities
			I412 - Number of managers trained in the methods and tools of innovation management
			I413 - Number of publications in scientific journals or conferences
			I414 - Number of information systems implemented
			I415 - Number of national and international patents
		Relational capital enhancement [O42]	I421 - Number of new co-created skills and knowledge in RD&I cooperation
			I422 - Number of external ideas/generated with customers
			I423 - Use of internal and external knowledge and information sources

After selecting the key indicators, a network model based on the analytic structure shown in Table 4.3 was determined, comprising the control and network layers. The control layer consists of seven strategic innovation goals (G11 to G13, G21, G31, G41, and G42), and the network layer is composed of 23 key innovation indicators, organized in clusters.

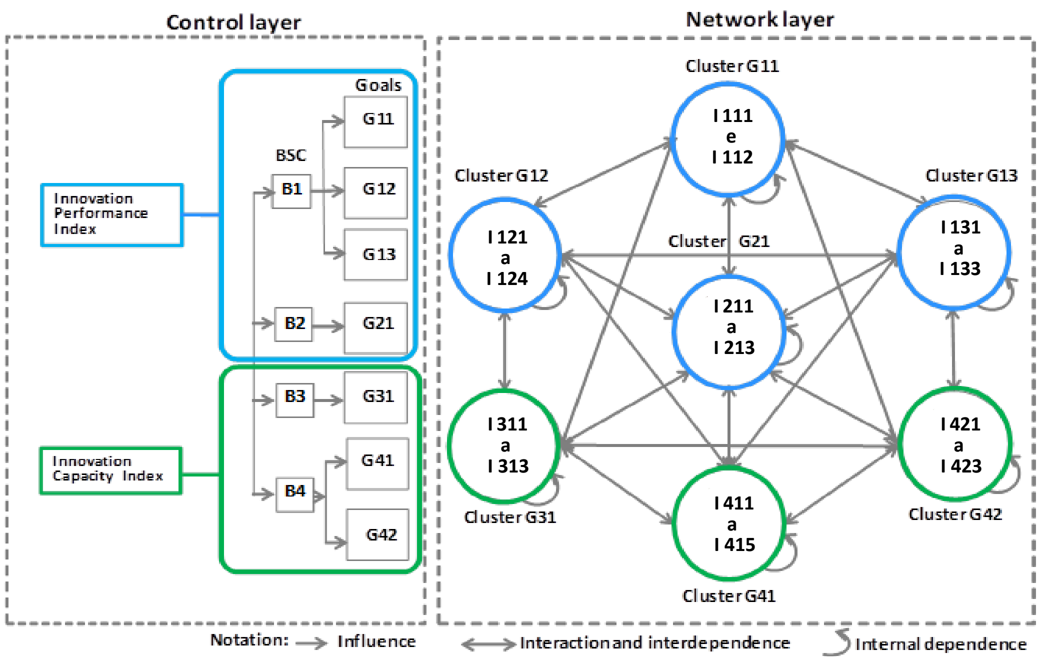

Figure 4.2 – The BSC-ANP model for measuring and evaluating the innovation capacity and performance of Companhia Alfa

Following the procedure described in Section 3.1, an interfactorial dominance matrix was built in a consensus–building session (Table 4.4).

Likewise, a control hierarchy matrix concerning the interactions among the strategic innovation goals (clusters in the network model) was formed by the seven goals listed in Table 4.3, i.e., a 7x7 matrix. If at least one element in a cluster influences one element in another cluster, they become related to each other, and the hierarchical matrix cell is filled in with '1'. If there is no influence of any element of a cluster on any element of another, this cell is ‘0’. As shown in Table 4.5, all clusters influence the others, confirming that the strategic innovation goals should form a network, with the cause-and-effect relationships objectively evidenced.

Table 4.4 – Interfactorial dominance matrix: empirical study in Companhia Alfa

Interfactorial dominance matrix		G11		G12				G13			G21			G31			G41					G42		
		I111	I112	I121	I122	I123	I124	I131	I132	I133	I211	I212	I213	I311	I312	I313	I411	I412	I413	I414	I415	I421	I422	I423
G11 – Innovation-based economic sustainability	**I111**	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1
	I112	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1
G12 – Innovation-based environmental sustainability	**I121**	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	I122	0	0	1	0	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	0	1	1	0
	I123	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1
	I124	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
G13 – Innovation-based social sustainability	**I131**	1	1	1	0	1	1	0	0	1	0	1	1	1	1	1	0	0	0	1	0	1	0	1
	I132	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
	I133	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1
G21 – Higher competitiveness and new markets due to innovation	**I211**	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0
	I212	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
	I213	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1
G31 – Innovation system management improvement	**I311**	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
	I312	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1
	I313	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
G41 – Human and structural capital enhancement	**I411**	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1
	I412	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1
	I413	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1
	I414	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1
	I415	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1
G41 – Relational capital enhancement	**I421**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0
	I422	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1
	I423	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	1	1	1	0	0	0

Source: Author's elaboration, based on results of meeting with the Innovation Manager and Technical Assistant.

Table 4.5 – Control hierarchy matrix: empirical study in Companhia Alfa

Control hierarchy matrix	**G11**	**G12**	**G13**	**G21**	**G31**	**G41**	**G42**
G11 - Innovation-based economic sustainability	0	1	1	1	1	1	1
G12 - Innovation-based environmental sustainability	1	0	1	1	1	1	1
G13 - Innovation-based social sustainability	1	1	0	1	1	1	1
G21 - Higher competitiveness and new markets due to innovation	1	1	1	0	1	1	1
G31 - Innovation management system improvement	1	1	1	1	0	1	1
G41 - Human and structural capital enhancement	1	1	1	1	1	0	1
G42 - Relational capital enhancement	1	1	1	1	1	1	0

Source: Author's elaboration, based on results of meeting with the Innovation Manager and Technical Assistant.

With the support of the Super Decisions® software (Creative Solutions, 2019), these connections were filled by the author in the 'Network' field, using the 'Make/ Show Connections' tab in the left corner, as shown in Figures 4.3 to 4.5).

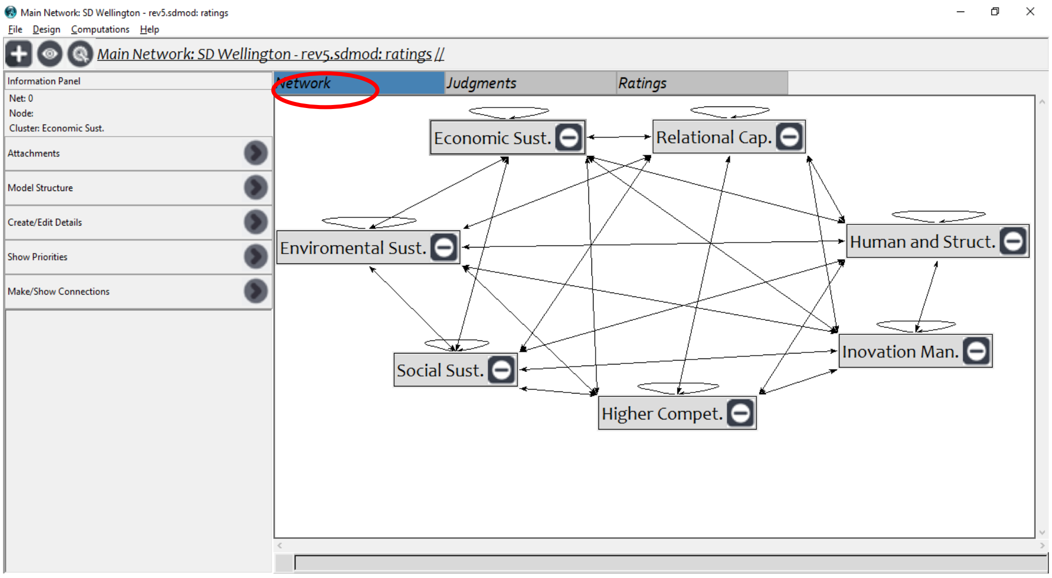

Figure 4.3 – Network structure in Super Decisions®: empirical study in Companhia Alfa

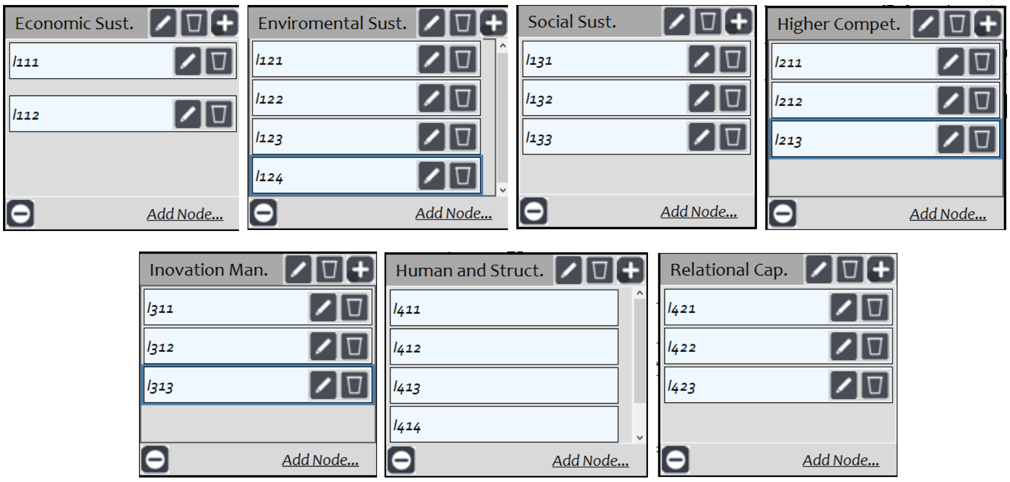

Figure 4.4 – Network structure deployment in Super Decisions®: empirical study in Companhia Alfa

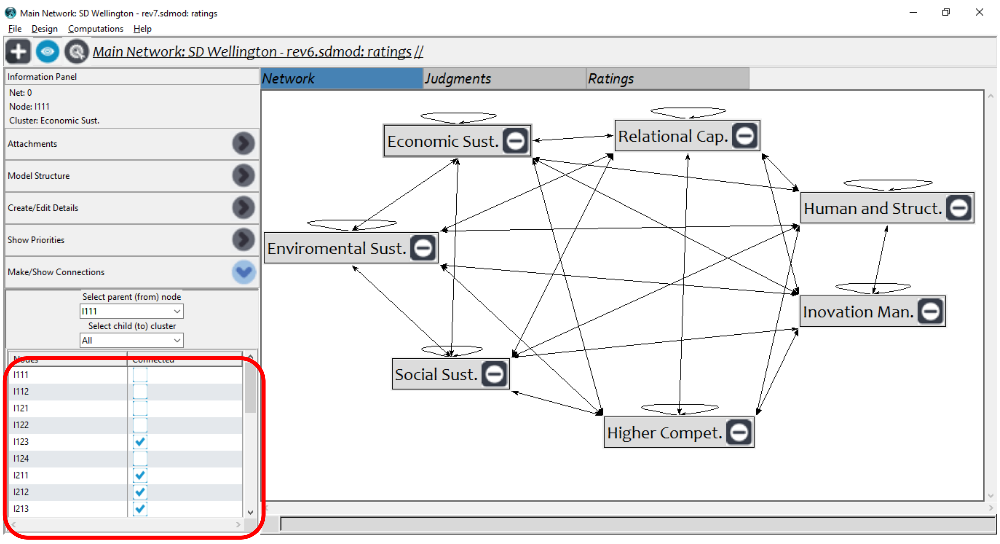

Figure 4.5 – Defining relationships between network elements in Super Decisions®: empirical study in Companhia Alfa

4.3.2. Stage 2: Design of a questionnaire for pairwise comparisons of the network elements and clusters

The questionnaire design for pairwise comparisons was based on the results of the interfactorial dominance matrix and the control hierarchy matrix. The questionnaire was pretested within a group of MSc. students in PósMQI/PUC-Rio to be further applied within the Companhia Alfa during stage 3 (Section 4.3 - Item 4.3.3).

4.3.3. Stage 3: Determination of importance weights of network elements and clusters

For determining the importance weights of the 23 network elements and seven clusters, Saaty's nine-point scale (Table 3.2) was used for pairwise comparisons conducted by three collaborators working in the Innovation Area of Companhia Alfa. For this, they used the pretested questionnaire and following the general instructions provided by the author. In this stage, the Super Decisions® continued to be used for calculating the unweighted and weighted super matrixes.

After consolidating judgments and preferences and testing the consistency ratios (C.R.), it was possible to generate the corresponding pairwise comparison matrices to obtain the corresponding eigenvectors. In this stage, an unweighted supermatrix could be built, as shown in Table 4.6.

Following the procedure described in item 3.3 (chapter 3), the value corresponding to the priority associated with a specific cluster determines the importance of its elements on which it acts (in the unweighted supermatrix). So, the weighted supermatrix was calculated with the support of Super Decisions ® software, combining the unweighted supermatrix and the results of the pairwise comparisons between the seven clusters. The latter scored a cluster weight in comparison to all others to which it was connected. A 7*7 matrix was built, corresponding to the network clusters (i.e., the seven strategic innovation goals).

Table 4.6 – Unweighted supermatrix: empirical study in Companhia Alfa

	I111	I112	I121	I122	I123	I124	I131	I132	I133	I211	I212	I213	I311	I312	I313	I411	I412	I413	I414	I415	I421	I422	I423
111	0,000	1,000	0,500	0,500	0,500	0,500	0,000	0,500	0,500	0,500	0,500	0,500	0,500	0,500	0,500	0,500	0,000	0,500	0,500	0,500	0,500	0,000	0,500
112	0,000	0,000	0,500	0,500	0,500	0,500	0,000	0,500	0,500	0,500	0,500	0,500	0,500	0,500	0,500	0,500	0,000	0,500	0,500	0,500	0,500	0,000	0,500
121	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,200	0,080	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
122	0,000	0,000	0,235	0,000	0,750	0,200	0,000	0,000	0,250	0,200	0,200	0,200	0,000	0,200	0,200	0,000	0,000	0,000	0,000	0,000	1,000	0,235	0,000
123	1,000	1,000	0,652	0,800	0,000	0,800	0,800	0,800	0,552	0,800	0,800	0,800	0,000	0,800	0,800	1,000	1,000	1,000	1,000	0,000	0,000	0,652	1,000
124	0,000	0,000	0,113	0,200	0,250	0,000	0,200	0,000	0,118	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,113	0,000
131	0,143	0,143	0,143	0,000	0,143	0,250	0,000	0,000	0,250	0,000	0,143	0,143	0,143	0,143	0,143	0,000	0,000	0,000	0,143	0,000	0,143	0,000	0,143
132	0,429	0,429	0,429	0,500	0,429	0,750	0,000	0,000	0,750	0,500	0,429	0,429	0,429	0,429	0,429	1,000	0,500	0,000	0,429	0,500	0,429	0,500	0,429
133	0,429	0,429	0,429	0,500	0,429	0,000	1,000	1,000	0,000	0,500	0,429	0,429	0,429	0,429	0,429	0,000	0,500	1,000	0,429	0,500	0,429	0,500	0,429
211	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,000	1,000	0,500	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,000
212	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	1,000	0,000	0,500	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,500
213	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,000	0,000	0,000	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,500
311	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,000	0,500	0,500	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333
312	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,000	0,000	0,500	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333
313	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333	1,000	0,500	0,000	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333
411	0,255	0,255	0,255	0,255	0,289	0,289	0,333	0,400	0,000	0,255	0,333	0,333	0,255	0,255	0,255	0,000	0,500	0,289	0,333	0,289	0,255	0,255	0,255
412	0,255	0,255	0,255	0,255	0,289	0,289	0,333	0,400	0,000	0,255	0,333	0,333	0,255	0,255	0,255	0,500	0,000	0,289	0,333	0,289	0,255	0,255	0,255
413	0,147	0,147	0,147	0,147	0,175	0,175	0,000	0,000	0,000	0,147	0,167	0,167	0,147	0,147	0,147	0,000	0,000	0,000	0,167	0,175	0,147	0,147	0,147
414	0,197	0,197	0,197	0,197	0,246	0,246	0,333	0,000	0,500	0,197	0,000	0,000	0,197	0,197	0,197	0,500	0,500	0,246	0,000	0,246	0,197	0,197	0,197
415	0,147	0,147	0,147	0,147	0,000	0,000	0,000	0,200	0,500	0,147	0,167	0,167	0,147	0,147	0,147	0,000	0,000	0,175	0,167	0,000	0,147	0,147	0,147
421	0,429	0,429	0,429	0,429	0,429	0,429	1,000	0,500	0,429	0,429	0,429	0,429	0,500	0,500	0,500	0,000	0,000	0,429	0,429	0,429	0,000	1,000	0,000
422	0,429	0,429	0,429	0,429	0,429	0,429	0,000	0,500	0,429	0,429	0,429	0,429	0,500	0,500	0,500	0,000	0,000	0,429	0,429	0,429	1,000	0,000	1,000
423	0,143	0,143	0,143	0,143	0,143	0,143	0,000	0,000	0,143	0,143	0,143	0,143	0,000	0,000	0,000	0,000	0,000	0,143	0,143	0,143	0,000	0,000	0,000

Source: Author's elaboration based on the calculation with Super Decisions® software.

Table 4.7 shows the resulting weights of the network clusters. In sequence, a weighted supermatrix could be obtained, as shown in Table 4.8.

Table 4.7 – Importance weights of the network clusters: empirical study in Companhia Alfa

Network clusters	Importance weight
G11 - Innovation-based economic sustainability	0,06395
G12 - Innovation-based environmental sustainability	0,06395
G13 - Innovation-based social sustainability	0,06395
G21 - Higher competitiveness and new markets due to innovation	0,11171
G31 - Innovation management system improvement	0,17199
G41 - Human and structural capital enhancement	0,25618
G42 - Relational capital enhancement	0,26828

Source: Author's elaboration based on the calculation with Super Decisions® software.

Table 4.8 - Weighted supermatrix: empirical study in Companhia Alfa

	I111	I112	I121	I122	I123	I124	I131	I132	I133	I211	I212	I213	I311	I312	I313	I411	I412	I413	I414	I415	I421	I422	I423
111	0,000	0,064	0,032	0,032	0,032	0,032	0,000	0,032	0,032	0,032	0,032	0,032	0,034	0,032	0,032	0,044	0,000	0,032	0,032	0,034	0,032	0,000	0,032
112	0,000	0,000	0,032	0,032	0,032	0,032	0,000	0,032	0,032	0,032	0,032	0,032	0,034	0,032	0,032	0,044	0,000	0,032	0,032	0,034	0,032	0,000	0,032
121	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,013	0,005	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
122	0,000	0,000	0,015	0,000	0,048	0,013	0,000	0,000	0,016	0,013	0,013	0,013	0,000	0,013	0,013	0,000	0,000	0,000	0,000	0,000	0,064	0,016	0,000
123	0,068	0,064	0,042	0,051	0,000	0,051	0,055	0,051	0,035	0,051	0,051	0,051	0,000	0,051	0,051	0,087	0,096	0,064	0,064	0,000	0,000	0,045	0,064
124	0,000	0,000	0,007	0,013	0,016	0,000	0,014	0,000	0,008	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,008	0,000
131	0,010	0,009	0,009	0,000	0,009	0,016	0,000	0,000	0,016	0,000	0,009	0,009	0,010	0,009	0,009	0,000	0,000	0,000	0,009	0,000	0,009	0,000	0,009
132	0,029	0,027	0,027	0,032	0,027	0,048	0,000	0,000	0,048	0,032	0,027	0,027	0,029	0,027	0,027	0,087	0,048	0,000	0,027	0,034	0,027	0,034	0,027
133	0,029	0,027	0,027	0,032	0,027	0,000	0,068	0,064	0,000	0,032	0,027	0,027	0,029	0,027	0,027	0,000	0,048	0,064	0,027	0,034	0,027	0,034	0,027
211	0,040	0,037	0,037	0,037	0,037	0,037	0,040	0,037	0,037	0,000	0,112	0,056	0,040	0,037	0,037	0,051	0,056	0,037	0,037	0,040	0,037	0,040	0,000
212	0,040	0,037	0,037	0,037	0,037	0,037	0,040	0,037	0,037	0,112	0,000	0,056	0,040	0,037	0,037	0,051	0,056	0,037	0,037	0,040	0,037	0,040	0,056
213	0,040	0,037	0,037	0,037	0,037	0,037	0,040	0,037	0,037	0,000	0,000	0,000	0,040	0,037	0,037	0,051	0,056	0,037	0,037	0,040	0,037	0,040	0,056
311	0,061	0,057	0,057	0,057	0,057	0,057	0,061	0,057	0,057	0,057	0,057	0,057	0,000	0,086	0,086	0,078	0,086	0,057	0,057	0,061	0,057	0,061	0,057
312	0,061	0,057	0,057	0,057	0,057	0,057	0,061	0,057	0,057	0,057	0,057	0,057	0,000	0,000	0,086	0,078	0,086	0,057	0,057	0,061	0,057	0,061	0,057
313	0,061	0,057	0,057	0,057	0,057	0,057	0,061	0,057	0,057	0,057	0,057	0,057	0,184	0,086	0,000	0,078	0,086	0,057	0,057	0,061	0,057	0,061	0,057
411	0,070	0,065	0,065	0,065	0,074	0,074	0,091	0,102	0,000	0,065	0,085	0,085	0,070	0,065	0,065	0,000	0,192	0,074	0,085	0,079	0,065	0,070	0,065
412	0,070	0,065	0,065	0,065	0,074	0,074	0,091	0,102	0,000	0,065	0,085	0,085	0,070	0,065	0,065	0,175	0,000	0,074	0,085	0,079	0,065	0,070	0,065
413	0,040	0,038	0,038	0,038	0,045	0,045	0,000	0,000	0,000	0,038	0,043	0,043	0,040	0,038	0,038	0,000	0,000	0,000	0,043	0,048	0,038	0,040	0,038
414	0,054	0,050	0,050	0,050	0,063	0,063	0,091	0,000	0,128	0,050	0,000	0,000	0,054	0,050	0,050	0,175	0,192	0,063	0,000	0,067	0,050	0,054	0,050
415	0,040	0,038	0,038	0,038	0,000	0,000	0,000	0,051	0,128	0,038	0,043	0,043	0,040	0,038	0,038	0,000	0,000	0,045	0,043	0,000	0,038	0,040	0,038
421	0,123	0,115	0,115	0,115	0,115	0,115	0,287	0,134	0,115	0,115	0,115	0,115	0,143	0,134	0,134	0,000	0,000	0,115	0,115	0,123	0,000	0,287	0,000
422	0,123	0,115	0,115	0,115	0,115	0,115	0,000	0,134	0,115	0,115	0,115	0,115	0,143	0,134	0,134	0,000	0,000	0,115	0,115	0,123	0,268	0,000	0,268
423	0,041	0,038	0,038	0,038	0,038	0,038	0,000	0,000	0,038	0,038	0,038	0,038	0,000	0,000	0,000	0,000	0,000	0,038	0,038	0,041	0,000	0,000	0,000

Source: Author’s elaboration based on the calculation with Super Decisions® software

4.3.4
Stage 4: Calculation of the limit supermatrix and resulting weights of the network elements

As mentioned in section 3.4, with the support of Super Decisions® software (Creative Decision Foundation, 2019), the author used a computations-limit matrix to calculate the limit supermatrix, which is derived from doing power operation on the weighted supermatrix, and its weighted value tends towards stability.

Table 4.9 shows the limit supermatrix calculated with the support of Super Decisions® software.

Table 4.9 – Limit supermatrix: empirical study in Companhia Alfa

	I111	I112	I121	I122	I123	I124	I131	I132	I133	I211	I212	I213	I311	I312	I313	I411	I412	I413	I414	I415	I421	I422	I423
I111	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027
I112	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025
I121	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04	6,E-04
I122	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015
I123	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045	0,045
I124	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
I131	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006
I132	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033
I133	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030
I211	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042	0,042
I212	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043	0,043
I213	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036
I311	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062	0,062
I312	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057
I313	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067	0,067
I411	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074	0,074
I412	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073	0,073
I413	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030	0,030
I414	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066	0,066
I415	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033	0,033
I421	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109
I422	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109	0,109
I423	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015

Source: Author's elaboration based on the calculation with Super Decisions® software.

Finally, the resulting weights of the 23 key innovation indicators (network elements) could be calculated, as shown in Table 4.10.

Table 4.10 – Importance weights of the network elements: empirical study in Companhia Alfa

Network element	Importance weight
I111 - Royalties of commercialized patents per year	0,0270
I112 - Net cash generated by commercialized patents and products per year	0,0254
I121 - GHG emissions reduction due to innovation	0,0006
I122 - Improvement in the use of renewable energies and energy efficiency due to innovation	0,0145
I123 - Number of innovative solutions to mitigate risk (operational risk, compliance risk, environmental risk)	0,0454
I124 - Number of innovative waste management solutions	0,0021
I131 - Involvement with local SMEs in supply chain management	0,0056
I132 - Start ups birth rate	0,0335
I133 - Number of innovations with social impacts	0,0299
I211 - Number of new or significantly improved products introduced onto the market	0,0419
I212 - Number of firms adopting the commercialized patents and products	0,0427
I213 - Market share of firms adopting the commercialized patents and products	0,0360
I311 - % of projects that developed new models, methods and/or standards to improve RD&I practices per year	0,062
I312 - Number of new business models or innovative solutions implemented through collaborative projects per year	0,057
I313 - Planning accuracy in innovation management, i.e., % of agreed milestones and/or objectives achieved	0,067
I411 - Number of employees devoted to RD&I activities	0,074
I412 - Number of managers trained in the methods and tools of innovation management	0,073
I413 - Number of publications in scientific journals or conferences	0,030
I414 - Number of information systems implemented	0,066
I415 - Number of national and international patents	0,033
I421 - Number of new co-created skills and knowledge in RD&I cooperation	0,109
I422 - Number of external ideas/generated with customers	0,109
I423 - Use of internal and external knowledge and information sources	0,015

Source: Author’s elaboration based on the calculation with Super Decisions® software.

The results presented in Table 4.10 demonstrate that, from the perspective of participants, the strategic innovation goals G42 and G41 concerning the “Learning and Growth” perspective have the greatest influence in the whole innovation management system of the company. The application of the BSC-ANP model allowed that the participants in pairwise comparisons could test the internal consistency of their judgments. So, the relative importance of the strategic innovation goals could be quantified by their influence on key innovation indicators, in total alignment with some of the guiding principles proposed by Dewangan and Godse (2014) and adopted in this research (see Section 2.2).

Figure 4.6 shows the network elements (key innovation indicators) by importance. As can be observed, the key indicators I421 (number of new co-created skills and knowledge in RD&I cooperation) and I422 (number of external ideas/generated with customers) achieved the highest positions in the ranking. These results can be explained by the fact that this company has adopted the open innovation model, whose core is a knowledge network. Companhia Alfa considered it a very valuable capacity for innovation of its own, whose objective, in essence, is to create sustainable competitive advantages rooted in mutually beneficial.

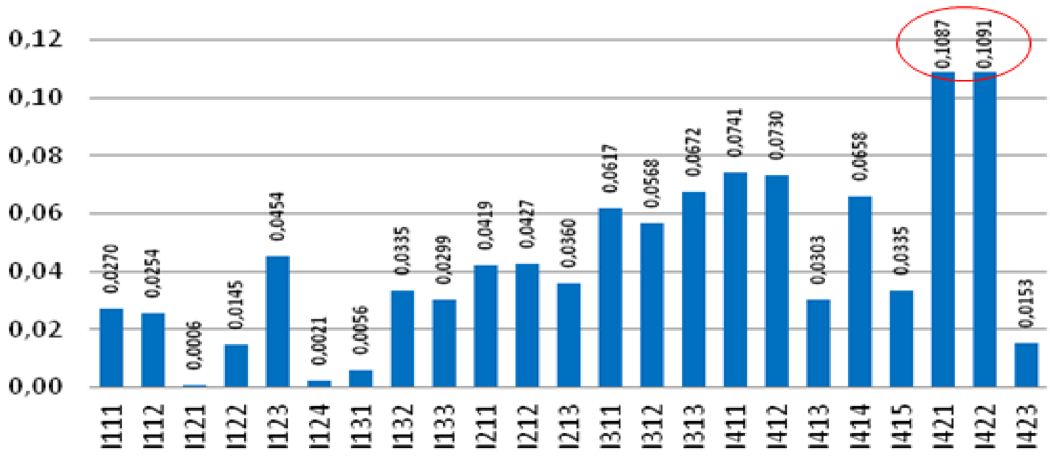

Figure 4.6 – Importance weights of the network elements: empirical study in Companhia Alfa

Source: Author’s elaboration based on the calculation with Super Decisions® software

4.3.5. Stage 5: Determination of the five-point scales for innovation capacity (IC) and innovation performance (IP) measurement

In this stage, the two five-point scales shown in Tables 3.2 and 3.3 were considered to be used in the next stage, as reported in item 4.3.6. The scales range from level 5 (high innovation capacity or performance) to level 1 (low innovation capacity or performance).

4.3.6 Stage 6: Application of the self-assessment instrument and calculation of the IC and IP indexes

The self-assessment instrument presented in Appendix 2 was elaborated and pretested within a group of MSc. students in PósMQI/PUC-Rio, taking the course in ‘Multicriteria Decision-making Methods’ in the second semester of 2020. Based on the network structure conceived in the BSC-ANP model, the instrument comprises questions on the network elements (23 key innovation indicators) organized around seven clusters (strategic innovation goals). For judgments, the

Innovation Manager and Technical Assistant used the five-point scales proposed in stage 5 of the model (Tables 3.2 and 3.3 shown in Chapter 3).

In Companhia Alfa, this instrument was filled out in a consensus-building meeting. The participants were asked to evaluate the current innovation capacity levels concerning the key innovation indicators associated with the lower BSC perspectives (‘Internal Process’ and ‘Learning and Growth’). Then, the five-point scale shown in Table 3.2 was used in this case.

Hence, the Innovation Capacity Index of Companhia Alfa was calculated by multiplying the ratings assigned by the participants with the relative weights of the 11 key innovation indicators associated with the lower BSC perspectives (‘Internal Process’ and ‘Learning and Growth’). The resulting IC Index could be calculated by summing them up.

The resulting IC Index (1,921) should be framed on a standard scale aiming to obtain the relative position of the company regarding its global innovation capacity (IC). After calculating the weights, it is possible to normalize the scales for classification of IC levels, as follows:

$$Min(ICI) = 1 * \sum_{i=I311}^{i=I423} Indicator\ weight \quad (1)$$

$$Max(ICI) = 5 * \sum_{i=I311}^{i=I423} Indicator\ weight \quad (2)$$

Between the Min(ICI) and Max(ICI) values, five ranges are established to fit the results according to the innovation capacity levels defined in the five-point scale (Table 3.3).

Table 4.11 shows how the Innovation Capacity Index of Companhia Alfa was calculated, and Table 4.12 refers to the ranges of innovation capacity levels associated with the respective five-point scale (Table 3.3).

Table 4.11 – Calculation of the Innovation Capacity Index of Companhia Alfa

Network elements associated with ‘Learning and Growth’ and ‘Internal Processes’ perspectives	Importance weight	Rating	Innovation capacity
I311 - % of projects that developed new models, methods and/or standards to improve RD&I practices per year	0,062	3	0,185
I312 - Number of new business models or innovative solutions implemented through collaborative projects per year	0,057	5	0,284
I313 - Planning accuracy in innovation management, i.e., % of agreed milestones and/or objectives achieved	0,067	4	0,269
I411 - Number of employees devoted to RD&I activities	0,074	2	0,148
I412 - Number of managers trained in the methods and tools of innovation management	0,073	3	0,219
I413 - Number of publications in scientific journals or conferences	0,030	1	0,030
I414 - Number of information systems implemented	0,066	2	0,132
I415 - Number of national and international patents	0,033	1	0,033
I421 - Number of new co-created skills and knowledge in RD&I cooperation	0,109	4	0,435
I422 - Number of external ideas/generated with customers	0,109	1	0,109
I423 - Use of internal and external knowledge and information sources	0,015	5	0,077
Innovation Capacity Index (ICI) of Companhia Alfa			**1,921**

To present the results on a clearer and simpler scale, analogous to the 5-point scale on which the indicators were evaluated, the ICI scale was normalized, as follows:

$$Min(ICI) = \frac{1 * \sum_{i=I311}^{i=I423} Indicator\ weight}{\sum_{i=I311}^{i=I423} Indicator\ weight} = 1 \quad (3)$$

$$Max(ICI) = \frac{5 * \sum_{i=I311}^{i=I423} Indicator\ weight}{\sum_{i=I311}^{i=I423} Indicator\ weight} = 5 \quad (4)$$

$$ICI = \frac{\sum_{i=I311}^{i=I423} Indicator\ weight * rating}{\sum_{i=I311}^{i=I423} Indicator\ weight} = \frac{1,921}{0,695} = 2,762 \quad (5)$$

Table 4.12 - Ranges of innovation capacity levels associated with the five-point scale (cf. Table 3.3)

Innovation capacity level	Description	Range	Normalized range
1. Low (L) innovation capacity	Low degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Internal Processes' and 'Learning and Growth' perspectives	0,695 – 1,2518	1 – 1,8
2. Low-medium (LM) innovation capacity	Low-medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Internal Processes' and 'Learning and Growth' BSC perspectives	1,2518 – 1,8082	1,8 – 2,6
3. Medium level (M) innovation capacity	Medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Internal Processes' and 'Learning and Growth' perspectives	1,8082 – 2,3646	2,6 – 3,4
4. Medium-high (MH) innovation capacity	Medium-high degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Internal Processes' and 'Learning and Growth' perspectives	2,3646 – 2,9209	3,4 – 4,2
5. High level (H) innovation capacity	High degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Internal Processes' and 'Learning and Growth' perspectives	2,9209 – 3,773	4,2 - 5

Source: Author's elaboration.

Accordingly, the final result the normalized ICI can be visualized in a dashboard, as shown in Figure 4.7 below.

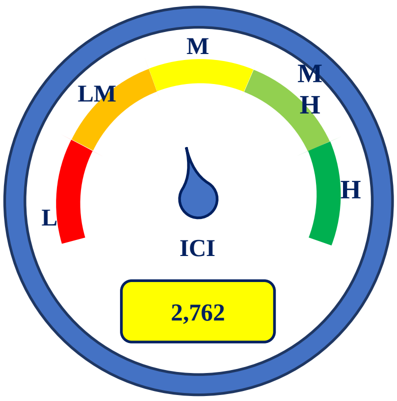

Figure 4.7 – Innovation Capacity Index of Companhia Alfa
Source: Author's elaboration.

Similarly, the Innovation Performance Index (IPI) could also be calculated, but in this case, the relative weights of 12 key innovation indicators will be those of the upper BSC perspectives (‘Market’ and ‘Sustainability’). The five-point scale shown in Table 3.3 was used in this case.

Table 4.13 refers to the composition of the Innovation Performance Index of Companhia Alfa, and Table 4.14 shows the ranges of innovation performance levels associated with the five-point scale (Table 3.4).

Table 4.13 – Calculation of the Innovation Performance Index of Companhia Alfa

Network elements associated with ‘Market’ and ‘Sustainability’ perspectives	Importance weight	Rating	Innovation performance
I111 - Royalties of commercialized patents per year	0,027	1	0,027
I112 - Net cash generated by commercialized patents and products per year	0,025	1	0,025
I121 - GHG emissions reduction due to innovation	0,001	4	0,002
I122 - Improvement in the use of renewable energies and energy efficiency due to innovation	0,015	3	0,044
I123 - Number of innovative solutions to mitigate risk (operational risk, compliance risk, environmental risk)	0,045	3	0,136
I124 - Number of innovative waste management solutions	0,002	2	0,004
I131 - Involvement with local SMEs in supply chain management	0,006	4	0,022
I132 - Startups birth rate	0,033	5	0,167
I133 - Number of innovations with social impacts	0,030	2	0,060
I211 - Number of new or significantly improved products introduced onto the market	0,042	3	0,126
I212 - Number of firms adopting the commercialized patents and products	0,043	3	0,128
I213 - Market share of firms adopting the commercialized patents and products	0,036	3	0,108
Innovation Performance Index (IPI) of Companhia Alfa			**0,850**

Source: Author’s elaboration.

The resulting IP Index (0,850) should be framed on a standard scale, aiming to obtain the company's relative position regarding its global innovation performance level. After calculating the weights, it is possible to normalize the scales for classification of IP levels, as follows:

$$Min(IPI) = 1 * \sum_{i=I111}^{i=I213} Indicator\ weight \quad (6)$$

$$Máx(IPI) = 5 * \sum_{i=I111}^{i=I213} Indicator\ weight \quad (7)$$

Between the Min(IPI) and Max(IPI) values, five ranges are established to fit the results according to the innovation performance levels defined in the five-point scale (table 3.4).

To present the results on a clearer and simpler scale, analogous to the 5-point scale on which the indicators were evaluated, the IPI scale was normalized, as follows:

$$Min(IPI) = \frac{1 * \sum_{i=I111}^{i=I213} Indicator\ weight}{\sum_{i=I111}^{i=I213} Indicator\ weight} = 1 \quad (8)$$

$$Max(IPI) = \frac{5 * \sum_{i=I111}^{i=I213} Indicator\ weight}{\sum_{i=I111}^{i=I213} Indicator\ weight} = 5 \quad (9)$$

$$IPI = \frac{\sum_{i=I111}^{i=I213} Indicator\ weight * rating}{\sum_{i=I111}^{i=I213} Indicator\ weight} = \frac{0{,}850}{0{,}305} = 2{,}791 \quad (10)$$

Table 4.14 – Ranges of innovation performance levels associated with the five-point scale (cf. Table 3.4)

Innovation performance level	Description	Range	Normalized range
1. Low innovation performance	Low degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Market' and 'Sustainability' BSC Perspectives	0,3046 – 0,5482	1 – 1,8
2. Low-medium innovation performance	Low-medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Market' and 'Sustainability' BSC Perspectives	0,5482 – 0,7919	1,8 – 2,6
3. Medium level innovation performance	Medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Market' and 'Sustainability' BSC Perspectives	0,7919 – 1,0355	2,6 – 3,4
4. Medium-high innovation performance	Medium-high degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Market' and 'Sustainability' BSC Perspectives	1,0355 – 1,2792	3,4 – 4,2
5. High level innovation performance	High degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Market' and 'Sustainability' BSC Perspectives	1,2792 – 1,5228	4,2 - 5

Source: Author's elaboration.

Figure 4.8 shows the normalized IPI in a dashboard representation.

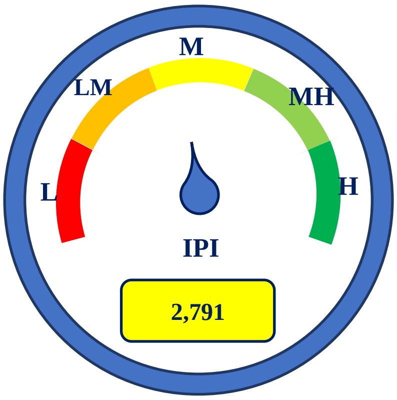

Figure 4.8 - Innovation Performance Index (IPI) of Companhia Alfa
Source: Author's elaboration.

4.4.
Discussion of results

The IC and IP indexes represented graphically in two dashboards (figures 4.7 and 4.8) were calculated in line with the weights defined for each key innovation indicator. These indexes can help managers in Companhia Alfa to define strategic RD&I initiatives to implement specific improvements in the areas of the organization that boost the innovation capacity and performance of this company. The fact that the most important key innovation indicators for Companhia Alfa are those associated with the "Learning and Growth" perspective corroborates the following assumptions: (i) competitiveness is associated with the ability of an organization to learn faster than your competition; and (ii) the ability to apply learning is central to the continuous improvement of the organization and the sustainable creation of value.

Innovation in an organization does not only correspond to the development and commercialization of new products or services, but it can also occur in the various links of its value chain. This perspective can be very appropriated by companies in the Brazilian electric sector since their products and services are very well defined, but their internal processes could be strongly influenced by innovative solutions addressed to increase competitiveness and sustainability (economic, environmental and social) in the short, medium and long term.

The flexibility of the BSC-ANP model was confirmed during the empirical study as a helpful measurement and evaluation tool able to be adapted to different organizational contexts. Particularly for the companies operating in the Brazilian electricity sector, it can be used as a benchmarking tool since a core set of key innovation indicators are agreed to be used as sectoral IC and IP metrics.

The model also provided reliable metrics for the weighting of the indicators, resulting from the cause-and-effect relationships between key indicators and strategic innovation goals, as represented graphically in Figure 4.2.

Despite the results of the model, two main limitations were identified during the development of this research concerning: (i) evaluation spectrum; and (ii) doubts during the self-assessment regarding the key indicators.

- Evaluation spectrum: the IC and IP Indexes were intentionally parameterized for the adopted five-point scales (Tables 3.2 and 3.3, respectively) and could be represented graphically in Figures 4.7 and 4.8. This was a methodological option for aligning the assessment results with the best-known monitoring practices (e.g., dashboard in multi-dimensional frameworks). Therefore, this option is in line with one of the guiding principles adopted for the modeling phase, i.e., easy implementation and use). However, the scales adopted at five levels can match companies in different stages, even though the graph's pointer can slide within each level.
- Doubts during the self-assessment regarding the key indicators: the well-elaborated description of the key indicators and metrics can allow the respondent to make a more coherent assessment of the company's innovation capacity or performance and minimize the risk of overvaluing its results. However, it does not exclude the possible doubt during the assessment since subjectivity is inherent to this process. The incorporation of fuzzy logic (Zadeh, 1965) for accommodating the inherent doubts of the assessment could make the model more effective in this sense. However, it would depend on a larger number of respondents to be effective.

5
Conclusions

The BSC-ANP model proposed in this dissertation proved itself to be an effective tool to help established organizations to measure and evaluate their innovation capacity and innovation performance. Then, it is possible to conclude that the general objective of this research was achieved.

From the literature and documentary analysis, 28 empirical studies on innovation capacity and performance measurement published between 1988 and 2020 were reviewed focusing on methodological issues. One first conclusion is that among the 28 studies, 15 adopted the scorecard approach (Kerssens-van-Drongelen and Cook, 1997; Wong, 2001; Verhaeghe and Kfir, 2002; Godener and Soderquist, 2004; Bremser and Barsky, 2004; Ojanen and Vuola, 2006; Gama et al., 2007; Chiesa and Frattini, 2009; Lazzarotti et al., 2011, Mohamed, 2013; Dewangan and Godse, 2014; Spanò et al., 2016; Zhang, 2016; Bican and Brem, 2020; and Dudic et al., 2020). So, this conclusion guided the choice of the BSC framework as the basis for the conceptual model object of this research.

An in-depth analysis of these 15 studies revealed a research gap regarding the use of a multicriteria decision-making approach which implements a networked structure and allows analyzing cause and effect relationships and feedback among strategic goals and key innovation indicators. The ANP method was chosen to integrate a BSC framework adapted for innovation management systems and proved to be effective to assign importance weights to the key innovation indicators associated with the strategic innovation goals of a given organization and also highlight the cause-and-effect relationships among them. Proceeding along this direction, one can conclude that the ANP method integrated with the BSC framework help organizations to handle the effects of dependencies across perspectives and over time. Only with a clearer understanding of the dependency issue would decision-makers be able to design and implement the innovation BSC as an effective organizational management system.

A third conclusion refers to the total alignment of the BSC-ANP model with the guiding principles recommended by Dewangan and Godse (2014) for designing an innovation capacity and performance measurement model from a strategic and systemic perspective, namely: (i) multidimensional orientation; (ii) innovation process orientation; (iii) cause-and-effect relationship orientation; (iv) stakeholder's goal-orientation; and (v) easy to implement and use.

The applicability of the BSC-ANP model proposed in this dissertation could be demonstrated through an empirical study conducted within an innovative company in the Brazilian electricity sector. Like many other empirical studies, it was situationally unique. Nevertheless, the general elements of the model and the methods employed (BSC and ANP) can be replicated by companies of other industrial sectors besides the electricity sector. It is also believed that dissemination of the proposed model can contribute to important organizational changes related to current innovation management systems and practices in established organizations.

These results refer to several specific objectives of this research and establish a basis for a more complex future work since the conceptual model here proposed is part of an ongoing research line in the Technology and Innovation Management (TIM) field within the Programa de Pós-graduação em Metrologia da PUC-Rio.

Last but not least, the results presented in Chapters 3 and 4 are addressed to answer two questions posed in the ANEEL Public Consultation n.017/2019, namely:

- How to assess the innovation capacity, and which indicators should be used to measure the level of innovation of a company in the electricity sector?
- What are the most relevant results that companies in the electricity sector should present as a product of the application of compulsory investments in RD&I?

Concerning the first question, the proposed BSC-ANP model was designed to help established organizations to improve their practices of measuring and evaluating innovation capacity and performance, and in particular, companies in the Brazilian electricity sector. Thus, the author who works for one of these companies invited the Companhia Alfa to demonstrate its applicability, highlighting the benefits for its own and other companies in the sector.

Finally, in relation to the second question, each company in the electricity sector should define its strategic innovation goals integrating them into the corporate strategic plan. So, based on the BSC-ANP model, those goals and key innovation indicators associated with them, that are classified in the upper BSC perspectives (‘Sustainability’ and ‘Market’), will be the managerial instruments for measuring and communicating the results of the application of compulsory investments in RD&I.

6
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Appendix 1
Innovation Indicators associated with the BSC framework

G11: Innovation-based Economic Sustainability		
Ref.	**Innovation Indicator**	**Literature review**
I111	Number of commercialized patents and products	Spanò et al. (2016);
I112	ROI of realized patents and products	Spanò et al. (2016); Dziallas and Blind (2019)
I113	Royalties of commercialized patents and products	Spanò et al. (2016); Dziallas and Blind (2019)
I114	Net cash generated by commercialized patents and products	Spanò et al. (2016); Dziallas and Blind (2019) Lazzarotti et al. (2011)
I115	Budget spent on research, development and innovation	Bicam and Brem (2020) Dziallas and Blind (2019) Lazzarotti et al. (2011)
I116	Share of research budget from total company budget	Dziallas and Blind (2019)
G12: Innovation-based Environmental Sustainability		
Ref.	**Innovation Indicator**	**Literature review**
I121	Number of projects with environmental relevance for the organization's region	Spanò *et al*. (2016);
I122	Pollution reduction due to innovations	Spanò *et al*. (2016);
I123	Improvement in the use of alternative energy/material due to innovations	Spanò *et al*. (2016);
I124	Number of procedures to mitigate risk (operational risk, compliance risk, environmental risk)	Spanò *et al*. (2016);
I125	Reduction of adverse events impact due to innovations	Spanò *et al*. (2016);
G13: Innovation-based Social Sustainability		
Ref.	**Innovation Indicator**	**Literature review**
I131	Number of key internal and external stakeholders integrated in the R&D projects to improve sustainability concerns sectors' value chains	Spanò et al. (2016); Dziallas and Blind (2019)
I132	Stakeholders' satisfaction rate	Spanò et al. (2016);
I133	Involvement of local SMEs	Spanò et al. (2016);
I134	Improvement in the occupational rate of the organization's region	Spanò et al. (2016);
I135	Innovative firms birth rate	Spanò et al. (2016);
I136	Number of Knowledge Transfer Sessions (KTS) organized to present Sustainability	Spanò *et al*. (2016);

	trends, novel technologies, etc.	
I137	Number of employees dedicated to external relationships in R&D	Lazzarotti *et al.* (2011)
I138	Number of alliances dedicated to technological innovation	Lazzarotti et al. (2011)
G21: Higher Competitiveness and New markets due to Innovation		
Ref.	**Innovation Indicator**	**Literature review**
I211	Degree of anticipation of internal customer needs	Bicam and Brem (2020)
I212	Number of new or significantly improved products (goods or services) for your enterprise was introduce onto the market	EUROSTAT. CIS_Survey
I213	Number of new or significantly improved products (goods or services) for your enterprise's market was introduce onto the market	EUROSTAT. CIS_Survey
I214	Number of firms adopting the commercialized patents and products	Spanò et al. (2016);
I215	Market share of firms adopting the commercialized patents and products	Spanò et al. (2016);
I216	Size of the company	Dziallas and Blind (2019)
I217	Geographic location of the company	Dziallas and Blind (2019)
I218	Age of company	Dziallas and Blind (2019)
I219	Market share, position and share	Dziallas and Blind (2019)
I2110	Number of innovative businesses/new venture start-ups	Dziallas and Blind (2019)
I2111	Customer complaints	Dziallas and Blind (2019)
I2112	New product introduction vs. competition	Dziallas and Blind (2019)
I2113	Annual spending for market investigations aimed at generating technological innovation	Lazzarotti et al. (2011)
G31: Innovation Management System Improvement		
Ref.	**Indicator**	**Literature review**
I311	Number of projects that developed new models, methods and/or standards to improve R&D practices	Spanò et al. (2016); EUROSTAT. CIS_Survey
I312	Number of new business models or frameworks developed and implemented through collaborative projects per year	Spanò et al. (2016);
I313	% of projects abandoned after a certain degree of completion	Bicam and Brem (2020) EUROSTAT. CIS_Survey
I314	Planning accuracy, i.e. % of agreed milestones and/or objectives met	Bicam and Brem (2020)
I315	Project progress and projects completed	Bicam and Brem (2020) EUROSTAT. CIS_Survey
I316	Time dedicated to the analysis of reasons for failure of previous projects	Lazzarotti et al. (2011)
I317	Percentage of innovation activities formally documented	Lazzarotti et al. (2011)
I318	Percentage of projects respecting established deadlines	Lazzarotti et al. (2011)

G41: Human and structural capital enhancement		
Ref.	**Innovation Indicator**	**Literature review**
I411	Number of joint training programs for researchers and employees	Spanò et al. (2016);
I412	Improvement of employees and researchers' satisfaction	Spanò et al. (2016) .
I413	Number of meeting among partners	Spanò et al. (2016)
I414	Number of publications in scientific journals or conferences	Spanò et al. (2016) OECD (2018)
I415	Number of national and international patents	Spanò et al. (2016) OECD (2018)
I416	Number of new intangibles per year (patents, licenses, copyrights, trademarks, etc.)	Spanò et al. (2016) OECD (2018) Lazzarotti et al. (2011)
I417	Number of projects funded by external organizations	Spanò et al. (2016) .
I418	Number of employees devoted to R&D	Lazzarotti et al. (2011)
I419	Hours spent on projects vs. total hours R&D	Bicam and Brem (2020)
I4110	Innovation level and degree of creativity	Bicam and Brem (2020)
I4111	Percentage of leaders trained in creativity techniques, atmosphere	Dziallas and Blind (2019)
I4112	Amount of time managers spent with innovations compared to normal tasks	Dziallas and Blind (2019)
I4113	Number of managers trained in the methods and tools of innovation	Dziallas and Blind (2019)
G42: Relational capital enhancement		
I421	Number of information systems implemented for sharing data	Spanò *et al*. (2016);
I422	Number of new co-created skills and knowledge	Spanò *et al*. (2016);
I423	Social engagement in the organization's region	Spanò *et al*. (2016);
I424	Transfer rate of new knowledge and technology into product development	Bicam and Brem (2020)
I425	% of new technology content in new products	Bicam and Brem (2020)
I426	Number of external ideas/generated with customers	Dziallas and Blind (2019)
I427	Number of newly created innovative opportunities	Dziallas and Blind (2019)
I428	Use of internal and external knowledge and information sources	Dziallas and Blind (2019)
I429	Percentage of projects using techniques such as design for assembly, design for manufacturing, design for logistic, design to cost	Lazzarotti et al. (2011)

Note: All references are listed in 'References' of the dissertation.

Appendix 2
Self-assessment instrument: Innovation Capacity and Performance

INSTRUMENTO DE AVALIAÇÃO DA CAPACIDADE INOVATIVA E DESEMPENHO INOVADOR DE EMPRESAS

Prezado participante,

O instrumento para medir a capacidade inovativa e desempenho inovador de empresas em geral e em particular do setor elétrico no Brasil faz parte de uma pesquisa de mestrado do Programa de Pós-Graduação em Metrologia da Pontifícia Universidade Católica do Rio de Janeiro (PósMQI/PUC-Rio). A pesquisa de mestrado tem por objetivo propor e demonstrar a aplicabilidade de um modelo para medir e avaliar a capacidade inovativa (IC) e o desempenho inovador (IP) de empresas, segundo uma abordagem *Balanced Scorecard* (BSC), combinada com um método multicritério de apoio à decisão.

Para a fase aplicada da pesquisa, construímos este instrumento que se baseou na literatura especializada sobre gestão estratégica da inovação, tendo como foco a aplicação da metodologia *Balanced Scorecard (BSC)* adaptada para esse processo organizacional.

Este instrumento está sendo aplicado na sua empresa com dois objetivos: (i) medir sua capacidade inovativa e desempenho inovador, visando contribuir para o aperfeiçoamento de seu sistema de gestão estratégica da inovação; e (ii) demonstrar a aplicabilidade do modelo conceitual desenvolvido no âmbito da referida pesquisa de mestrado.

O instrumento está estruturado em quatro seções, que correspondem às dimensões da abordagem *Balanced Scorecard*, ou seja: (i) 'Aprendizado e Crescimento'; (ii) 'Processos Internos'; (iii) 'Mercado'; (iv) 'Sustentabilidade'. Às duas primeiras dimensões, associam-se indicadores-chave de capacidade inovativa, enquanto que nas dimensões seguintes os indicadores-chave visam medir e avaliar o desempenho inovador. Na página seguinte, apresentamos a estrutura analítica adotada neste instrumento.
Antecipadamente, expressamos o nosso agradecimento pela sua disponibilidade, participação e colaboração.

Atenciosamente,

Wellington Luiz Leite Rocha
Mestrando do Programa PósMQI/PUC-Rio

Maria Fatima Ludovico de Almeida
Profª Orientadora da pesquisa de mestrado no PósMQI/PUC-Rio

ESTRUTURA ANALÍTICA ADOTADA NESTE INSTRUMENTO

Indice	Perspectiva BSC	Objetivo Estratégico de Inovação	Indicadores-chave
Índice de Desempenho Inovador (IP)	Sustentabilidade (1)	Sustentabilidade econômica com base em inovação [O11]	I111 - *Royalties* recebidos pelas patentes de produtos comerciliazados (por ano)
			I112 – Faturamento líqudo por patentes de produtos comerciliazados e por novos produtos (por ano)
		Sustentbilidade ambiental com base em inovação [O12]	I121 - Redução de emissões de gases efeito estufa devido à inovação
			I122 - Aumento do uso de energias renováveis e eficiência energética devido a inovação
			I123 – Número de soluções inovadoras geerdas para mitigar riscos (operacionais, ambientais ou de não-atendimento à legislação/regulamentação apicável)
			I124 – Número de soluções inovadoras para gerenciamento de resíduos
		Sustentabilidade social com base em inovação [O13]	I131 – Engajamento de pequenas e médias empresas locais e inovadoras na gestão da cadeia de suprimento.
			I132 – Taxa de criação de start-ups, futuras fornecedoras da empresa
			I133 – Número de soluções inovadoras com impactos sociais
	Mercado (2)	Aumento de competitividade pelas inovações e entrada em novos mercados [O21]	I211 – Número de produtos novos ou significativamente novos lançados no mercado (últimos 3 anos)
			I212 – Número de empresas clientes adotando patentes ou usando novos produtos comercializados pela empresa
			I213 - Market share das empresas clientes adotando patentes ou produtos comercializados pela empresa
Ìndice de Capacidade Inovativa (IC)	Processos Internos (3)	Gestão da inovação para resultados [O31]	I311 - % of projetos que desenvolveram novos modelos, métodos ou procedimentos para melhoria das práticas de P&D e inovação (por ano)
			I312 – Número de novos modelos de negócio ou soluções inovadoras implementadas por meio de projetos colaborativos (por ano)
			I313 – Eficiência do planejamento em gestão da inovação. i.e. ações e metas realizadas versus ações e metas planejadas.
	Aprendizado e Crescimento (4)	Fortalecimento do capital humano e estrutural para inovar [O41]	I411 – Número de empregados dedicados às atividades de P&D e inovação
			I412 - Número de gerentes capacitados ´para emprego de métodos e ferramentas de gestão da inovação
			I413 - Número de publicações em revisas científicas ou anais de congressos
			I414 - Número de sistemas de informação implementados para suporte aos processos de gestão da inovão na empresa
			I415 - Número de patentes nacionais e internacionais
		Fortalecimento do capital relacional para inovar [O42]	I421 - Novas habilidades e conhecimentos criados pela cooperação em projetos de P&D e invoação.
			I422 - Número de ideias inovadoras geradas com participação de clientes
			I423 – Uso de conhecmento e fontes de informação internas e externas para inovar

CARACTERIZAÇÃO DA EMPRESA

Nome da empresa:
Razão social da empresa:
Setor de atuação (Classificação CCNAE/IBGE – 4 dígitos): *Exemplo: 2473-2/00 – Fabricação de artigos de perfumaria e cosméticos.*
Ano de fundação:
Endereço principal e telefone(s):
Número de empregados:
Origem do capital controlador: *O capital controlador é nacional quando está sob titularidade direta ou indireta de pessoas físicas ou jurídicas residentes e domiciliadas no país. O capital controlador é estrangeiro, quando está sob titularidade direta ou indireta de pessoas físicas ou jurídicas domiciliadas fora do país.*
Quais os principais desafios que a empresa enfrenta para inovar?
A empresa tem um processo de gerenciamento estratégico da inovação? que ferramentas de gestão emprega?
Cargo do respondente na empresa:

ORIENTAÇÕES GERAIS PARA PREENCHIMENTO

As primeiras seções referem-se às perspectivas BSC 'Aprendizado e Crescimento' e 'Processos Internos' e visam avaliar a **capacidade inovativa** da empresa em relação a um conjunto de indicadores-chave associados a cada uma dessas dimensões. Ao responder as questões dessas duas seções, você deverá adotar a escala de cinco níveis, apresentada abaixo. Às respostas (marcadas com x), seguem-se justificativas correspondentes a seus julgamentos.

Nível	Capacidade inovativa	Descrição
1	Baixa capacidade inovativa	Baixa capacidade inovativa expressa pelo alcance inferior a 30% das metas e ações associadas ao indicador em foco.
2	Baixa-média capacidade inovativa	Baixa-média capacidade inovativa expressa pelo alcance de 30 a 49 % das metas e ações associadas ao indicador em foco.
3	Média capacidade inovativa	Média capacidade inovativa expressa pelo alcance de 50 a 69 % das metas e ações associadas ao indicador em foco.
4	Média-alta capacidade inovativa	Média capacidade inovativa expressa pelo alcance de 60 a 89% das metas e ações associadas ao indicador em foco.
5	Alta capacidade inovativa	Alta capacidade inovativa expressa pelo alcance de 90 a 100% das metas e ações associadas ao indicador em foco.

Conceito de capacidade inovativa (IC): capacidade da empresa de integrar e coordenar recursos humanos, financeiros, técnicos e organizacionais, objetivando a geração de soluções inovadoras para atender necessidades dos clientes e da sociedade.

Já as questões da terceira e quarta seções referem-se às dimensões - 'Mercado' e 'Sustentabilidade' e visam avaliar o **desempenho inovador** da empresa em relação aos indicadores-chave associados a cada uma dessas dimensões. Ao responder as questões, você deverá adotar a escala em cinco níveis, como apresentada abaixo. Às respostas (marcadas com x), seguem-se as justificativas correspondentes a cada nível indicado.

Nível	Desempenho inovador	Descrição
1	Baixo desempenho inovador	Baixo desempenho inovador expresso pelo alcance inferior a 30% das metas e ações associadas ao indicador em foco
2	Baixo-médio desempenho inovador	Baixo-médio desempenho inovador expresso pelo alcance de 30 a 49 % das metas e ações associadas ao indicador em foco
3	Médio desempenho inovador	Médio desempenho inovador expresso pelo alcance de 50 a 69 % das metas e ações associadas ao indicador em foco
4	Médio-alto desempenho inovador	Médio-alto desempenho inovador expresso pelo alcance de 60 a 89% das metas e ações associadas ao indicador em foco
5	Alto desempenho inovador	Alto desempenho inovador expresso pelo alcance de 90 a 100% das metas e ações associadas ao indicador em foco

Conceito de desempenho inovador (IP): expressa em que medida a governança, condições, recursos e processos orientados para inovação traduzem-se em resultados econômico-financeiros, operacionais e de mercado, além de benefícios socioambientais.

INSTRUMENTO DE AUTO-DIAGNÓSTICO DA CAPACIDADE INOVATIVA E DESEMPENHO INOVADOR DE EMPRESAS

Seção 1 – Perspectiva BSC 'Aprendizado e Crescimento'

OBJETIVO ESTRATÉGICO O41: Fortalecimento do capital humano e estrutural para inovar. **INDICADORES-CHAVE**	**CAPACIDADE INOVATIVA**				
	BAIXA	**MÉDIA-BAIXA**	**MÉDIA**	**MÉDIA-BAIXA**	**ALTA**
I411 – Número de empregados dedicados às atividades de P&D e inovação					
I412 – Número de gerentes capacitados ´para emprego de métodos e ferramentas de gestão da inovação					
I413 – Número de publicações em revisas científicas ou anais de congressos					
I414 – Número de sistemas de informação implementados para suporte aos processos de gestão da inovão na empresa					
I415 – Número de patentes nacionais e internacionais					
NÍVEL ATUAL DA CAPACIDADE INOVATIVA [AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]					

OBJETIVO ESTRATÉGICO O41: Fortalecimento do capital humano e estrutural para inovar. **INDICADORES-CHAVE**	**CAPACIDADE INOVATIVA**				
	BAIXA	**MÉDIA-BAIXA**	**MÉDIA**	**MÉDIA-BAIXA**	**ALTA**
I421– Novas habilidades e conhecimentos criados pela cooperação em projetos de P&D e invoação.					
I422 – Número de ideias inovadoras geradas com participação de clientes					
I423 – Uso de conhecmento e fontes de informação internas e externas para inovar					
NÍVEL ATUAL DA CAPACIDADE INOVATIVA [AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]					

Seção 2 – Perspectiva BSC ‘Processos Internos’

OBJETIVO ESTRATÉGICO O31: Gestão da inovação para resultados	**CAPACIDADE INOVATIVA**				
INDICADORES-CHAVE	**BAIXA**	**MÉDIA-BAIXA**	**MÉDIA**	**MÉDIA-BAIXA**	**ALTA**
I311 – % of projetos que desenvolveram novos modelos, métodos ou procedimentos para melhoria das práticas de P&D e inovação (por ano)					
I312 – Número de novos modelos de negócio ou soluções inovadoras implementadas por meio de projetos colaborativos (por ano)					
I313 – Eficiência do planejamento em gestão da inovação. i.e. ações e metas realizadas *versus* ações e metas planejadas.					

NÍVEL ATUAL DA CAPACIDADE INOVATIVA [AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

Seção 3 – Perspectiva BSC ‘Mercado’

OBJETIVO ESTRATÉGICO O21: Aumento de competitividade pelas inovações e entrada em novos mercados	**DESEMPENHO INOVADOR**				
INDICADORES-CHAVE	**BAIXO**	**MÉDIO-BAIXO**	**MÉDIO**	**MÉDIO-BAIXO**	**ALTO**
I211 – Número de produtos novos ou significativamente novos lançados no mercado (últimos 3 anos)					
I212 – Número de empresas clientes adotando patentes ou usando novos produtos comercializados pela empresa					
I213 – *Market share* das empresas clientes que adotaram patentes ou usam produtos comercializados pela empresa					

NÍVEL ATUAL DO DESEMPENHO INOVADOR [AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

Seção 3 – Perspectiva BSC 'Sustentabilidade'

OBJETIVO ESTRATÉGICO O11: Sustentabilidade econômica com base em inovações **INDICADORES-CHAVE**	**DESEMPENHO INOVADOR**				
	BAIXO	**MÉDIO-BAIXO**	**MÉDIO**	**MÉDIO-BAIXO**	**ALTO**
I111 – Royalties recebidos pelas patentes de produtos comercializados (por ano)					
I112 – Faturamento líqudo por patentes de produtos comercializados e por novos produtos comercializados (por ano)					
NÍVEL ATUAL DO DESEMPENHO INOVADOR [AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]					

OBJETIVO ESTRATÉGICO O12: Sustentabilidade ambiental com base em inovações **INDICADORES-CHAVE**	**DESEMPENHO INOVADOR**				
	BAIXO	**MÉDIO-BAIXO**	**MÉDIO**	**MÉDIO-BAIXO**	**ALTO**
I121 - Redução de emissões de gases efeito estufa devido à inovação					
I122 - Aumento do uso de energias renováveis e eficiência energética devido a inovação					
I123 – Número de soluções inovadoras geerdas para mitigar riscos (operacionais, ambientais ou de não-atendimento à legislação/regulamentação apicável)					
I124 – Número de soluções inovadoras para gerenciamento de resíduos					
NÍVEL ATUAL DE DESEMPENHO INOVADOR [AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]					

OBJETIVO ESTRATÉGICO O12: Sustentabilidade social com base em inovações **INDICADORES-CHAVE**	**DESEMPENHO INOVADOR**				
	BAIXO	**MÉDIO-BAIXO**	**MÉDIO**	**MÉDIO-BAIXO**	**ALTO**
I131 – Engajamento de pequenas e médias empresas locais e inovadoras na gestão da cadeia de suprimento.					
I132 – Taxa de criação de *start-ups*, futuras fornecedoras da empresa					
I133 – Número de soluções inovadoras com impactos sociais					

NÍVEL ATUAL DO DESEMPENHO INOVADOR [AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

COMENTÁRIOS ADICIONAIS:

Agradecemos mais uma vez pela sua disponibilidade e contribuição para esta pesquisa!

Appendix 3
Self-assessment of Innovation Capacity and Performance of Companhia Alfa

- **Seção 1 – Perspectiva BSC 'Sustentabilidade'**

OBJETIVO ESTRATÉGICO O11: Sustentabilidade econômica com base em inovações	**AVALIAÇÃO**				
INDICADORES-CHAVE	**BAIXA**	**MÉDIA-BAIXA**	**MÉDIA**	**MÉDIA-ALTA**	**ALTA**
I111 – Royalties recebidos pelas patentes de produtos comercializados (por ano)	x				
I112 – Faturamento líquido por patentes de produtos comercializados e por novos produtos comercializados (por ano)	x				

[AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

Somos uma empresa de geração e comercialização de energia. Logo, os desenvolvimentos de Inovação não têm por tradição criar novos produtos. Estamos fazendo os primeiros desenvolvimentos de produtos mais recentemente, mas estes serão aplicados em nossas próprias operações e comercializados pela empresa parceira desenvolvedora mediante acordo comercial a ser definido conosco. O pagamentos de royalties está sendo considerado.

OBJETIVO ESTRATÉGICO O12: Sustentabilidade ambiental com base em inovações	**AVALIAÇÃO**				
INDICADORES-CHAVE	**BAIXA**	**MÉDIA-BAIXA**	**MÉDIA**	**MÉDIA-ALTA**	**ALTA**
I121 - Redução de emissões de gases efeito estufa devido à inovação				x	
I122 - Aumento do uso de energias renováveis e eficiência energética devido a inovação			x		
I123 – Número de soluções inovadoras geerdas para mitigar riscos (operacionais, ambientais ou de não-atendimento à legislação/regulamentação apicável)			x		
I124 – Número de soluções inovadoras para gerenciamento de resíduos		x			

[AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

Como empresa geradora de energia via combustível fóssil, os desenvolvimentos em geral vêm buscando aumentar eficiência das plantas e desenvolver novas linhas de receita para a companhia.

I121 - A melhor eficiência da planta se traduz em menores emissões. Adicionalmente buscamos trabalhar com temas como captura de carbono e reaproveitamento de resíduos desde os princípios dos investimentos da companhia. No entanto, estes são temas ainda com baixo TRL e com maior necessidade de evolução. Pelo menos 3 projetos dedicados ao tema.

OBJETIVO ESTRATÉGICO O13: Sustentabilidade social com base em inovações	AVALIAÇÃO				
INDICADORES-CHAVE	BAIXA	MÉDIA-BAIXA	MÉDIA	MÉDIA-ALTA	ALTA
I131 – Engajamento de pequenas e médias empresas locais e inovadoras na gestão da cadeia de suprimento.				x	
I132 – Taxa de criação de *start-ups*, futuras fornecedoras da empresa					x
I133 – Número de soluções inovadoras com impactos sociais		x			

[AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

O viés de inovação em parceria com start-ups têm sido bastante perseguido. Desenvolvendo-se produtos a quatro mãos para novas ofertas conjuntas ou mesmo para atendimento de necessidades da própria companhia.

I131 e I132 – Trabalhando-se com 7 startups no ciclo 2019/2020 na criação de novas soluções.

I133 – Não rastrado.

- **Seção 2 – Perspectiva BSC 'Mercado'**

OBJETIVO ESTRATÉGICO O21: Aumento de competitividade pelas inovações e entrada em novos mercados	AVALIAÇÃO				
INDICADORES-CHAVE	BAIXA	MÉDIA-BAIXA	MÉDIA	MÉDIA-ALTA	ALTA
I211 – Número de produtos novos ou significativamente novos lançados no mercado (últimos 3 anos)			x		
I212 – Número de empresas clientes adotando patentes ou usando novos produtos comercializados pela empresa			x		
I213 – *Market share* das empresas clientes que adotaram patentes ou usam produtos comercializados pela empresa			x		

[AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

Tradicionalmente não houve foco no desenvolvimento de novos produtos. Estes desenvolvimentos são mais recentes, do últimos 1,5 ano. Os projetos estão, portanto, começando a entrar em conclusão e consequente mensuração de impactos.

I211 – 4 novos produtos/serviços em finalização do desenvolvimento para lançamento no mercado em 2021. Um deles com envolvimento de outros 4 grandes players do setor no seu desenvolvimento.

- **Seção 3 – Perspectiva BSC 'Processos Internos'**

OBJETIVO ESTRATÉGICO O31: Gestão da inovação para resultados **INDICADORES-CHAVE**	AVALIAÇÃO				
	BAIXA	MÉDIA-BAIXA	MÉDIA	MÉDIA-ALTA	ALTA
I311 – % of projetos que desenvolveram novos modelos, métodos ou procedimentos para melhoria das práticas de P&D e inovação (por ano)			x		
I312 – Número de novos modelos de negócio ou soluções inovadoras implementadas por meio de projetos colaborativos (por ano)					x
I313 – Eficiência do planejamento em gestão da inovação. i.e. ações e metas realizadas *versus* ações e metas planejadas.				x	

[AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

Os projetos mais voltados a metas pré-definidas ainda estão em fase de maturação para avaliação mais profunda. Foram definidos portfólios de alocação dos recursos e estes têm sido devidamente cumpridos. A finalização dos projetos e mensuração de seus impactos está no radar para os próximos anos.

I312 – 7 projetos relacionados a novos modelos / soluções inovadoras selecionados com startups no ciclo 2019/2020

I313 – Cumprimento de todas as metas de Inovação no ciclo 2020.

- **Seção 4 – Perspectiva BSC 'Aprendizado e Crescimento'**

OBJETIVO ESTRATÉGICO O41: Fortalecimento do capital humano e estrutural para inovar. **INDICADORES-CHAVE**	AVALIAÇÃO				
	BAIXA	MÉDIA-BAIXA	MÉDIA	MÉDIA-ALTA	ALTA
I411 – Número de empregados dedicados às atividades de P&D e inovação		x			
I412 – Número de gerentes capacitados ´para emprego de métodos e ferramentas de gestão da inovação			x		
I413 – Número de publicações em revisas científicas ou anais de congressos	x				
I414 – Número de sistemas de informação implementados para suporte aos processos de gestão da inovão na empresa		x			
I415 – Número de patentes nacionais e internacionais	x				

[AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

I411 – Equipe muito enxuta (3 pessoas) apoiada por prestadores de serviços especializados.

I412 – De forma dedicada, apenas 1, mas vários gerentes já se envolveram em projetos de P&D.

I413 – Não rastreado.

I414 – Superior a 4 (incluindo sistemas de gestão de uma maneira geral). Sistemas especializados, apenas 1.

I415 – Não rastreado.

OBJETIVO ESTRATÉGICO O42: Fortalecimento do capital relacional para inovar.	AVALIAÇÃO				
INDICADORES-CHAVE	BAIXA	MÉDIA-BAIXA	MÉDIA	MÉDIA-ALTA	ALTA
I421 – Novas habilidades e conhecimentos criados pela cooperação em projetos de P&D e inovação.				x	
I422 – Número de ideias inovadoras geradas com participação de clientes	x				
I423 – Uso de conhecmento e fontes de informação internas e externas para inovar					x

[AVALIAÇÃO QUALITATIVA – EVIDÊNCIAS POR INDICADOR]

I421 – Sensação qualitativa – falta de indicador próprio para afirmar isto.

I422 – Pela natureza da operação (geração de energia), a Inovação é mais direcionada pela participação de fornecedores técnicos.

I423 – Trabalho com instituições do Brasil e exterior, hubs de startups, fornecedores, operações etc.