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Measuring and Evaluating Organizational Innovation Capacity and Performance from Systemic and Sustainability-Oriented Perspective

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Abstract: In the last decades, several multidimensional models for measuring and evaluating the innovation capacity and performance of organisations have been designed by researchers and consulting firms and adopted by established innovative organisations worldwide. However, the topic of measurement and evaluation models that are designed for sustainability-oriented innovation management has remained underexplored by researchers and practitioners. From this perspective, this work proposes a conceptual model for measuring and evaluating the sustainability-oriented innovation capacity (SOIC) and performance (SOIP) of established organisations, guided by the following principles: a multidimensional structure, stakeholder goal orientation, interdependence and feedback loop analyses, innovation process orientation and ease of implementation and use. In line with these principles, the proposed model combines the balanced scorecard (BSC) framework with a hybrid multicriteria methodological approach. Furthermore, it considers the interdependencies between the key innovation indicators (KIIs), which are classified according to four perspectives of an adapted BSC framework. The proposed conceptual model, and the empirical results that demonstrate its applicability in an organisational context, may contribute to improving the current practices for measuring and evaluating the SOIC and SOIP, which could help organisations to adjust their strategies to create sustainable value for the new era of business.

Keywords: sustainability-oriented innovation; innovation management; R&D management; balanced scorecard; multicriteria decision-making methods

1. Introduction

Since the Brundtland Report, the concept of sustainable development (SD) has evolved beyond the initial intergenerational framework to a focus on socially inclusive and environmentally sustainable economic growth [1]. Nowadays, SD refers to achieving a balance between individual systems that require interdisciplinary initiatives over time for local, national, regional or organisational decision-making issues. Remarkably, within the UN 2030 Agenda framework, the United Nations established 17 Sustainable Development Goals (SDGs) in 2015 as a global call to action to end poverty, protect the environment and ensure that by 2030, people enjoy peace and prosperity [2]. Furthermore, considering the central role of Science, Technology and Innovation (STI) for SDGs implementation, the Agenda calls for a global Technology Facilitation Mechanism (TFM) to enable international cooperation regarding access to STI, and to enhance knowledge sharing to achieve the SDGs [3,4]. In addition, there is a call to enhance the STI capacity of developing countries, and to promote the development and use of emerging technologies to achieve the SDGs in these countries [4,5].

At the organisational level, sustainability-oriented innovations (SOIs) are addressed to create and realise social and environmental value, in addition to economic returns, by

making intentional changes to an organisation's philosophy and values, as well as to its products, processes or practices [6–10].

Innovative organisations enhance their general competence bases and stimulate learning processes, which may benefit themselves and other organisations. Thus, the innovation capability refers to the ability to understand changes in business environments, grasp market opportunities and create new knowledge and solutions internally or in collaboration with strategic partners [11].

According to Lawson and Samson, organisations with this innovation capability have "the ability to integrate key capabilities and resources to stimulate innovation successfully" [12] (p. 380). Based on [6–10,13], we can define the SOI capability as the dynamic ability to adapt, integrate and reconfigure organisational skills, resources and functional competencies to respond to contemporary sustainability challenges.

The methodological approaches for measuring innovation capabilities that are relevant for research on strategic innovation management have focused on the following: (i) the resources controlled by the organisation; (ii) the organisation's general management capabilities, including the capabilities related to managing innovation activities; (iii) the human capital and how the organisation manages it; (iv) the ability to develop and use technological tools and data resources, with the latter providing an increasingly important source of information for innovation [14].

In this regard, some researchers have defined new indicators and investigated the factors behind the innovation performance throughout the RD&I processes (e.g., [15]). Several multidimensional innovation performance measurement models have been designed in the last decades to address this need. Most of these models combine financial and nonfinancial indicators to measure the organisation's tangible and intangible assets and value. Some outstanding examples are the balanced scorecard (BSC) [16–18] and the performance prism frameworks [19,20].

The BSC framework has been used by organisations for the strategic monitoring and evaluation of their business performance. It is a methodological approach that employs lead and lag indicators that are aligned to the organisation's vision, mission and value statements. This approach assumes that the business performance can be evaluated considering financial and nonfinancial indicators [16–18]. It is considered a helpful tool to measure the innovation capacity and performance at the organisational level, but only if a reasonable attempt to adapt the original framework for this purpose has been made.

Two streams can be distinguished among the previous works that have adapted the BSC framework to measure and evaluate the innovation capacity and performance [21–42]. The first stream emphasises the measurement and evaluation of the R&D outcomes and processes [21–27], while the second focuses on the innovation capacity performance [28–42].

We summarise 22 empirical studies in Appendix B (Table A3) to show that considerable research has been dedicated to developing and applying models for measuring and evaluating the innovation capacity and performance based on adaptations of the original BSC framework. However, despite these efforts, two research gaps could be identified.

The first gap refers to the use of an MCDM approach to analyse the interdependencies and feedback loops among the strategic innovation goals and key innovation indicators associated with the BSC perspectives. Although some multicriteria decision-making (MCDM) methods have been used to model BSC frameworks for various purposes [43,44], no previous studies have adapted the original Kaplan and Norton model to measure and evaluate the R&D or innovation performance at the organisational level [21–42] using MCDM approaches.

Notwithstanding the importance of the results achieved so far, a second research gap was found: none of the previous models for measuring and evaluating the innovation capacity and performance adhere to the principles of multidimensional structure, interdependence and feedback loop analyses, innovation process orientation and easy implementation, as suggested by Dewangan and Godse [34], for the design of holistic innovation performance measurement systems.

Considering the following:

- Nowadays, the BSC approach is a methodological reference that guides organisations to determine their corporate performance by means of leading and lagging indicators that are aligned with their visions and business strategies;
- The concepts of innovative capacity and performance are second-order constructs of innovation management, and they are operationalised in the form of interdependencies and feedback loops;
- The literature review on the measurement and evaluation of RD&I management revealed that various previous works essentially focused on the adaptation of the original BSC model and the identification of the RD&I indicators associated with the BSC perspectives;
- The feedback and interdependencies among the networked elements of the SOIC and SOIP constructs have been neglected in previous works;
- The integration of a multicriteria decision-making approach into an adapted BSC framework for sustainability-oriented innovation management has remained unknown to researchers and managers;
- A methodological approach that combines an adapted BSC framework with a multicriteria approach can significantly contribute to improving the current practices for measuring and evaluating the innovation capacity and performance of established organisations from a sustainability-oriented strategic vision.

This paper addresses the research gaps by investigating the following research questions:

- RQ1: How do we measure and evaluate the sustainability-oriented innovation capacity (SOIC) and performance (SOIP) of established organisations while adhering to the principles of multidimensional structure, interdependency and feedback analyses, innovation process orientation and easy implementation?
- RQ2: What innovation indicators should be considered in an adapted BSC framework for modelling the sustainability-oriented innovation capacity (SOIC) and performance (SOIP) measurement and evaluation of established organisations, considering the lack of a sustainability focus in the presented literature?
- RQ3: What measurement scales should be integrated into this model to evaluate the the SOIC and SOIP of established organisations?
- RQ4: To what extent can the analytic network process (ANP) and hybrid analytic hierarchy process (AHP)/technique for order of preference by similarity to ideal solution (TOPSIS) method contribute to improving the focused process in innovative organisations, considering that complexity, multidimensionality and uncertainty are inherent to this type of process?

From a systemic and sustainability-oriented perspective, this paper proposes a model for measuring and evaluating the SOIC and SOIP of established organisations based on an adapted BSC framework combined with a multicriteria decision-making approach. In comparison with the previous studies reviewed in this work, we highlight the fundamental methodological differences as follows:

- The adaptation of the original BSC framework to incorporate social and environmental dimensions into the organisation's strategy, considering that the process associated with sustainability-oriented innovation is a nonlinear construct that should be integrated into the business strategies of organisations;
- The alignment of the conceptual model with the guiding principles defined by Dewangan and Godse [34] for designing a model for measuring and evaluating the innovation capacity and performance of established organisations;
- The use of the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods to select the key innovation indicators (KIIs) associated with each BSC perspective, which provides managers with flexibility when choosing the best ones according to the organisation's business environment;

- With the support of the Analytic Network Process (ANP) method, a network can be formed of the strategic innovation goals (SIGs) and KIIs (network clusters), incorporating the feedback and interdependent relationships within and between these networked elements;
- The SOIC indicators and metrics are associated with the lower BSC perspectives, (i.e., 'Internal Process' and 'Learning and Growth'), while the SOIP indicators and metrics refer to the upper BSC perspectives (i.e., 'Sustainability' and 'Market');
- The SOIC and SOIP indexes can be graphically represented in dashboard format. It is a methodological option to align the assessment results with the best-known monitoring practices (e.g., dashboards in multidimensional frameworks). Therefore, this option aligns with one of the guiding principles adopted for the modelling phase: easy implementation and use.

The article is structured in six sections. Following the introduction, Section 2 briefly presents the research design and adopted methodology. Section 3 introduces the conceptual model for measuring and evaluating the SOIC and SOIP of organisations, aligned with the principles of multidimensional structure, interdependence and feedback loop analyses, innovation process orientation and easy implementation. Section 4 presents and discusses the results of an empirical study conducted on an innovative company in the Brazilian electricity sector, with the aim of demonstrating the applicability of the proposed model in a corporate environment. The SOIC and SOIP indexes could be calculated from the assessment of the current situation of the SOIC and SOPI associated with the 23 key innovation indicators that integrate the company's corporate sustainability strategy. In Section 5, we discuss the contributions of the proposed model compared with those of previous works, as well as the managerial implications for innovative organisations that aim to incorporate the social and environmental dimensions, in addition to economic ones, into their innovation and business strategies. Lastly, Section 6 synthesises the concluding remarks and future developments of this research for those interested in advancing the knowledge on the "Innovation Management and Organizational Performance for Sustainable Future".

2. Research Design and Methodology

The research design encompassed three phases and six stages, following a procedural model based on Martins et al. [45], to provide an underlying structure and approved course of action for this research. This section describes the research methods for addressing the questions posed in Table 1. Accordingly, the research phases are as follows: (i) motivation; (ii) conceptualisation and development; (iii) validation.

Associated with these three phases, the stages described in Table 1 are as follows: Stage 1: the problem definition and rationale for the research; Stage 2: the state of the research in terms of the central themes, and the identification of the research gaps and unsolved problems in the focused field; Stage 3: the definition of the research methodology; Stage 4: the development of the conceptual model for measuring and evaluating the SOIC and SOIP of organisations; Stage 5: the application of the conceptual model in the context of an innovative company in the electricity sector in Brazil; Stage 6: a discussion of the research results and implications of the adoption of the proposed model by other sustainability-oriented organisations.

The first two stages covered a literature review of scientific articles and reference documents published between 1992 and 2022 to obtain the conceptual and empirical works related to the central themes of this research. For this, systematic searches were carried out in the leading scientific production databases (e.g., Scopus, Web of Science), as detailed in Appendix A (Tables A1 and A2). These searches were complemented with subsequent searches on Google Scholar, and afterwards, the bibliographic review was deepened, with an analysis of the references cited in the most relevant articles (backward search). As a result, we identified and selected 22 previous studies that adapted the original Kaplan and Norton model to measure and evaluate the R&D or innovation performance at the organisational level [21–42], as summarised in Appendix B (Table A3).

Table 1. Research design.

Phase	Stage	Research Question (Section)
Motivation (Why?)	Problem definition and rationale for research	Why should we develop a conceptual model for measuring and evaluating the innovation capacity and performance from a systemic and sustainability-oriented perspective? (Section 1)
Conceptualisation and Development (What and How?)	State of research on central themes and identification of research gaps and unsolved problems	What are the substantial gaps in the existing knowledge on the models for measuring and evaluating the SOIC and SOIP of established organisations? (Section 1)
	Definition of research methodology	How could a conceptual model for measuring the SOIC and SOIP of organisations be developed and validated in a real organisational context? (Section 2)
	Development of conceptual model for measuring and evaluating the SOIC and SOIP of established organisations at the corporate level	How do we measure and evaluate the SOIC and SOIP of established organisations while adhering to the principles of multidimensional structure, interdependence and feedback loop analyses, innovation process orientation and easy implementation? (Section 3) What SOI indicators should be considered in the BSC framework for modelling a process for measuring and evaluating SOIC and SOIP at the corporate level? (Section 3) What measurement scales should be integrated into the model to evaluate the SOIC and SOIP of organisations? (Section 3)
Validation (How to demonstrate the applicability of the conceptual model)	Application of conceptual model in context of innovative company in electricity sector in Brazil (the Alpha Company (fictitious name)).	Is it feasible to demonstrate the applicability of the proposed model by developing an empirical study conducted on the Alpha Company with the RD&I manager and technical assistants? (Section 4) What key innovation indicators were chosen to integrate the analytical network structure during the assessment process? (Section 4) What are the company's SOIC and SOIP indexes? (Section 4)
	Discussion of research results and implications of adoption of model by other sustainability-oriented organisations.	Can the results of the empirical study conducted on the Alpha Company demonstrate the applicability of the proposed model? (Section 5) What are the main differentials of the proposed model concerning the methodological approaches covered by the literature review in the introductory section? (Section 5) What are the managerial implications for innovative organisations that aim to incorporate social and environmental perspectives, in addition to the economic one, into their innovation strategies? (Section 5)

The third stage refers to the definition of the research methodology, which comprises the following: (i) a literature review of the scientific articles and documents published between 1992 and 2022 on the central research themes, selecting the most relevant works, as mentioned before; (ii) the development of a conceptual model for measuring and evaluating the SOIC and SOIP of organisations, aligned with the following guiding principles: multidimensional structure, interdependence and feedback loop analyses, innovation process orientation and easy implementation and use; (iii) the development of an empirical study on an innovative company in the Brazilian electricity sector to demonstrate the conceptual model's applicability in an organisational context.

A conceptual model was developed in the fourth stage, guided by the four principles. This model comprises six stages, as follows: (i) the determination of the analytical network structure based on the BSC framework [16–18], with the support of the ANP and TOPSIS methods; (ii) the design and pretesting of a questionnaire for pairwise comparisons of the elements that integrate the analytical structure defined in Stage 1; (iii) pairwise comparisons for determining the importance weights of the network elements and clusters; (iv) the calculation of the limit supermatrix and resulting weights of the network elements; (v) the

determination of five-point scales for measuring the SOIC and SOIP of a given organisation; (vi) the application of the self-assessment instrument and the calculation of the SOIC and SOIP indexes.

Finally, in the validation phase, an empirical study was developed on an innovative company in the Brazilian electric sector to demonstrate the applicability of the conceptual model proposed in the previous phase. From the empirical findings presented in Section 4, we discuss the implications of adopting the proposed model in other sustainability-oriented organisations.

3. Conceptual Model for Measuring Organisation Innovation Performance

This section introduces the conceptual model for measuring and evaluating the SOIC and SOIP of established organisations, which is schematically represented in Figure 1.
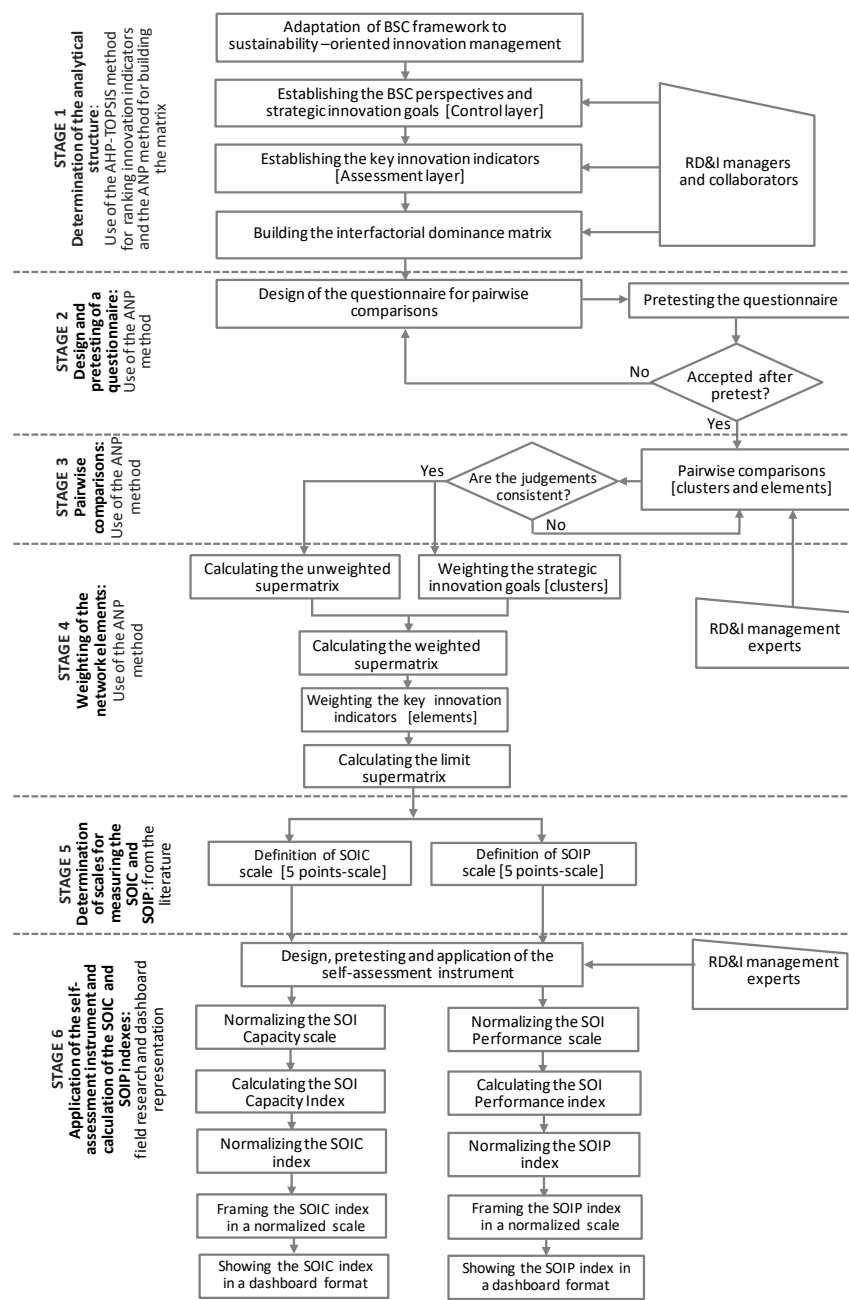

Figure 1. General view of conceptual model for measuring and evaluating SOIC and SOIP of established organisations.

Aligned with the guiding principles proposed in [34], and based on the BSC framework combined with the ANP and TOPSIS methods, the conceptual model comprises six stages, as follows:

- The determination of the analytic network structure based on the BSC framework, with the support of the ANP and hybrid AHP/TOPSIS methods;
- The design and pretesting of a questionnaire for pairwise comparisons of the network elements and clusters that integrate the analytical structure defined in Stage 1;
- Pairwise comparisons for determining the importance weights of the network elements and clusters;
- The calculation of the limit supermatrix and resulting weights of the network elements;
- The determination of two five-point scales for measuring the SOIC and SOIP levels;
- The application of the self-assessment instrument and calculation of the SOIC and SOIP indexes.

3.1. Stage 1: Determination of an Analytic Network Structure Based on BSC Framework

Based on the BSC framework [16–18] and principle of operability, the SOIC and SOIP levels of organisations can be measured and evaluated considering four assessment perspectives: (1) 'Sustainability' (B1); (2) 'Market' (B2); (3) 'Internal Process' (B3); (4) 'Learning and Growth' (B4). These perspectives were adapted from the original Kaplan and Norton perspectives for application in the strategic innovation management processes of established organisations with strategies that are oriented towards sustainability.

Figge et al. [46] argued that the BSC framework can encompass all the relevant aspects for achieving sustainability in a balanced manner. The sustainable BSC, as they proposed, is a framework for measuring, managing and reporting the results of sustainable corporate strategies. Butler et al. [47] suggested three alternative scenarios for creating a sustainable BSC: (i) the integration of the environmental and social aspects into the existing four original dimensions; (ii) the creation of a fifth perspective to include social and environmental aspects in the strategy map; (iii) the formulation of a specific environmental or social scorecard.

Based on [46,48], we then considered the first scenario by proposing a "Sustainability" (B1) perspective that is aligned to the triple-bottom-line sustainability approach [47]. In other words, this perspective integrates economic (corresponding to Kaplan and Norton's original "Financial" perspective), environmental and social sustainability.

In addition, similar to the BSC model proposed by Spanò et al. [38], the strategic innovation goals were associated with the four BSC perspectives after the mentioned adaptation. Therefore, the top managers within organisations should establish their strategic innovation goals as part of their sustainability-oriented strategic planning, the results of which can be schematically represented in a 'strategy map', as conceived by Kaplan and Norton [18].

After establishing the strategic innovation goals associated with the four adapted BSC perspectives, RD&I managers and collaborators should define the key innovation indicators that integrate the analytical network structure for the SOIC and SOIP measurement and evaluation.

It is important to mention that the key innovation indicators and metrics must be chosen by each organisation, and they depend on the organisation's business strategy. Accordingly, these indicators should be selected among the various innovation indicators reported in previous works [21–42], reference documents and surveys adopted by regional and national initiatives to measure the innovation capacity and performance of companies. An example is the Community Innovation Survey (CIS) in Europe [49], which is based on the guidelines proposed by the Organisation for Economic Co-operation and Development (OECD) for collecting and interpreting technological innovation data [14].

Established organisations can conduct this step in light of the criteria for selecting the indicators usually adopted in the field of monitoring and evaluation [50–52], starting from

an initial list of innovation indicators gathered from the literature and reference documents (see Appendix C, Table A4).

The following criteria for ranking and selecting good-quality innovation indicators are suggested for use in this stage:

- C1—Relevance: The innovation indicator should be a valid measure of the result/ outcome of a sustainability-oriented innovation strategy;
- C2—Measurability: The innovation indicator can be counted, observed, analysed, tested or challenged. If one cannot measure an indicator, then the progress towards the strategic innovation goal achievement cannot be evaluated;
- C3—Accuracy: Accurate indicators are considered correct. The data measure what they are intended to measure: the progress toward the strategic innovation goal achievement;
- C4—Credibility: The innovation indicator has been recommended and used by leading experts and organisations in the context of innovation management and sustainability (for example, the Global Network for Economics of Learning, Innovation, and Competence Building Systems (Globelics));
- C5—Precision: Precision means that the data collected have sufficient detail concerning the innovation indicator;
- C6—Timeliness: The innovation indicator must be timely in several aspects. The monitoring and evaluation system (and related innovation indicators) allows for the cost-effective tracking of the progress at the desired frequency for a set period.

Before ranking and selecting the innovation indicators from the BSC perspective, the following weights were assigned to the above criteria with the support of the Analytic Hierarchy Process method [53]: C1: 0.217; C2: 0.217; C3: 0.115; C4: 0.120; C5: 0.116; C6: 0.215.

The TOPSIS method was chosen [54] to rank the innovation indicators using a scale with linguistic terms, as shown in Table 2.

Table 2. Linguistic terms for ranking importance of innovation indicators.

Level of Importance	Definition
1	Very unimportant
2	Between very unimportant and unimportant
3	Unimportant
4	Between very unimportant and medium
5	Medium
6	Between medium and important
7	Important
8	Between important and very important
9	Very important

The TOPSIS method comprises five steps: (i) the consensual judgment by RD&I managers and collaborators concerning the performance of the innovation indicators in light of each criterion; (ii) the identification of the positive ideal solutions (A+ (benefits)) and negative ideal solutions (A− (costs)); (iii) the calculation of the Euclidean distances from the positive ideal solution (PIS) and negative ideal solution (NIS) of each innovation indicator from the BSC perspective; (iv) the calculation of the closeness coefficient of each alternative indicator concerning the PIS; (v) the determination of the ranking order of all the key innovation indicators for each BSC perspective. The best alternatives are those with higher closeness coefficient (CCi) values, and therefore they should be chosen because they are closer to the PIS. This procedure should be performed for each BSC perspective. All the formulas and parameters used in this procedure can be found in [54].

Once the strategic innovation goals associated with the four BSC perspectives are established and the respective key innovation indicators are selected, an analytic network structure for measuring and evaluating the SOIC and SOIP can be defined, as detailed in Table 3.

Table 3. Analytical network structure for measuring and evaluating SOIC and SOIP of established organisations.

Target Layer (A)	Control Layer		Assessment Layer
	BSC Perspective (B)	**Strategic Innovation Goal (SIG)**	**Key Innovation Indicator (KII)**
To measure and evaluate sustainability-oriented innovation performance (SOIP)	Sustainability (B1)	SIG11	From I111 to I11n
		SIG12	From I121 to I12n
		… …	… …
		SIG1n	From I1n1 to I1nn
	Market (B2)	SIG21	From I211 to I21n
		SIG22	From I221 to I22n
		… …	… …
		SIG2n	From I2n1 to I2nn
To measure and evaluate sustainability-oriented innovation capacity (SOIC)	Internal Processes (B3)	SIG31	From I311 to I31n
		SIG32	From I321 to I32n
		… …	… …
		SIG3n	From I3n1 to I3nn
	Learning and Growth (B4)	SIG41	From I411 to I41n
		SIG42	From I421 to I42n
		… …	… …
		SIG4n	From I4n1 to I4nn

The control layer in Table 3 consists of four BSC perspectives and respective strategic innovation goals (from SIG11 to SIG4n). In turn, the assessment layer is composed of 'n' key innovation indicators (KIIs), which are organised in clusters that correspond to the strategic innovation goals (from SIG11 to SIG4n). Therefore, they must also be defined by the top managers within the organisation. It is essential to mention that the 'strategy map' that is composed of the strategic business goals (including the SIGs), key indicators and initiatives is unique for each organisation.

For measuring and evaluating the SOIC and SOIP of established organisations, the next step is to determine the influences among the key innovation indicators (KIIs). First, a zero–one interfactorial dominance matrix is built, the elements of which take the value of 1 or 0, depending on whether there is (or is not) some influence of one element on another. The matrix's rows and columns are formed by 'n' KIIs, which are grouped into clusters that correspond to the strategic innovation goals (SIGs).

Before going any further, it is essential to emphasise that the four BSC perspectives are equally important in this conceptual model for measuring and evaluating the SOIC and SOIP of established organisations. Thus, in this network model, the pairwise comparisons are restricted to the strategic innovation goals (clusters) and respective key innovation indicators (assessment factors).

3.2. Stage 2: Design and Pretesting of Questionnaire for Pairwise Comparisons of Assessment and Control Elements

The design of a questionnaire for pairwise comparisons should consider the key innovation indicators (assessment layer) and strategic innovation goals (control layer) that integrate the analytic network structure represented in Figure 2.
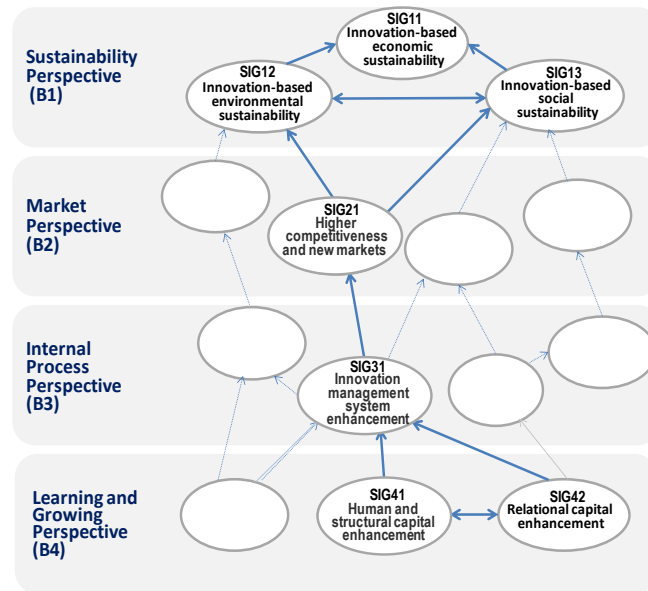
Figure 2. Schematic representation of 'strategy map' of Alpha Company. **Note:** The seven strategic innovation goals are highlighted in the strategy map of the Alpha Company. Unfilled ellipses represent strategic goals from other business areas.

Table 4 presents Saaty's nine-point scale for paired comparisons [55,56].

Table 4. Saaty's nine-point scale for paired comparisons.

Level of Importance	Definition
1	Same importance
2	Preference between 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

In this stage, a pretesting of the questionnaire must be undertaken with the participation of innovation management experts to evaluate its clarity, suitability to the respondents, the required time to answer the questions and the possible obstacles that could arise during its application. The final version of 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 (ii) With what intensity? For this, the nine-point scale proposed by Saaty [55,56] must be adopted, as shown in Table 4.

After being validated, the questionnaire is ready to be applied to the managers and collaborators engaged in the RD&I activities within the organisation in focus. Suppose

there are a number of experts involved in this evaluation. In this case, a consensus can be achieved in a consensus-building meeting [55,56], or by employing fuzzy logic to compute the collective weightings from the individual judgements [57].

3.3. Stage 3: Pairwise Comparisons for Determining Importance Weights of Assessment and Control Elements

In the third stage, Saaty's nine-point scale (see Table 4) should be used for the pairwise comparisons of the assessment and control elements conducted by the RD&I managers and collaborators involved with the innovation management within the organisation.

When adopting the ANP method, the managers or panel of experts who make judgments or preferences must go through the consistency test that is conducted based on the consistency ratios (CRs) of the pairwise comparison matrixes. This is the ratio of the consistency index to the corresponding random value. The methodological details can be found in [55,56]. The corresponding pairwise comparison matrices are generated to obtain the corresponding eigenvectors (unweighted supermatrix).

The value that corresponds to the priority associated with a specific cluster determines the importance of the elements on which it acts (in the unweighted supermatrix). Thus, the weighted supermatrix can be generated. The weighted supermatrix results from combining the unweighted supermatrix and control hierarchy matrix (i.e., the pairwise comparison of the strategic innovation goals). The latter scores a cluster weight in comparison with all the 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, a Ci cluster is first chosen. Then, all the others connected with the Ci are pairwise compared to determine their impact on the Ci. In this way, a weighted supermatrix can be obtained. Afterwards, the matrix is limited, and the consolidation of the interdependency and relative weights are gradually derived. Accordingly, a weighted supermatrix can be obtained.

The weights of the selected key innovation indicators can be calculated with the support of Super Decisions® software version 2.8 [58] following these two last steps, as follows: (i) the use of the design-cluster-new order to establish the clusters; (ii) the use of the design-node-new order to establish the element nodes; (iii) the use of do-connections-order to establish the internal connections (internal dependency) within the same cluster, as well as the connections (external dependency) among different clusters; (iv) the use of the assess/compare-pairwise comparison order to compare the relations between the clusters and element nodes according to Saaty's nine-point scale (Table 4), and to generate a comparison matrix; (v) the use of the computations-unweighted supermatrix order to calculate the unweighted supermatrix, which is aligned to the comparison matrix; (vi) the use of the computations-weighted supermatrix order to calculate the weighted supermatrix, which represents the degree of the global dominance of the corresponding element nodes. The sum of the elements in the columns is 1.

3.4. Stage 4: Calculation of Limit Supermatrix and Resulting Weights of Network Elements

With the support of Super Decisions® 2.8 [58], a computations-limit matrix can be used to calculate the limit supermatrix, which is derived from performing power operations on the weighted supermatrix. Its weighted value tends towards stability. Gradually, the consolidation of the interdependency and relative importance weights are obtained.

3.5. Stage 5: Determination of Five-Point Scales for Measuring SOIC and SOIP

The objective of this stage is to propose two five-point scales based on the common characteristics of previous works [59–62]. Weerawardena [59] examined the role of the marketing capabilities in a competitive-innovation-based strategy. The research helps to refine and validate the measures of entrepreneurship, marketing skills, organisational innovation and sustained competitive advantage. In turn, Alegre et al. [60] proposed scales for valid measures concerning two key performance dimensions: the effectiveness and efficiency of the product innovation. Calik et al. [61] developed an initial scale to evaluate

the sustainable innovation performance. This study presented the first known scale to measure the sustainable innovation performance, and it can be used by organisations to evaluate sustainable product or process innovation performance. A year later, Calik et al. [62] proposed a scale for innovation capability measurement that was based on a survey conducted with enterprises in Turkey.

For this model, we defined two scales that range from Level 5 (high SOIC or SOIP) to Level 1 (low SOIC or SOIP) (Tables 5 and 6).

Table 5. Five-point scale for measuring sustainability-oriented innovation capacity (SOIC) at organisation level.

SOIC 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	A high degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Internal Processes' and 'Learning and Growth' BSC perspectives.

Table 6. Five-point scale for measuring sustainability-oriented innovation performance (SOIP) at organisation level.

SOIP 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 achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Market' and 'Sustainability' BSC perspectives.
5. High-level innovation performance	A high degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Market' and 'Sustainability' BSC perspectives.

These scales should be adopted during the self-assessment conducted by RD&I managers and collaborators within organisations that are measuring and evaluating their SOIC and SOIP levels (see the description in the next section).

3.6. Stage 6: Application of Self-Assessment Instrument and Calculation of SOIC and SOIP Indexes

In this stage, the design of the self-assessment instrument should consider 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 5 of the model (see Tables 5 and 6). Pretesting must be undertaken in this stage to evaluate the instrument's clarity, suitability to the respondents and required time to answer the questions.

After being validated, the self-assessment instrument is ready to be applied to the managers and collaborators engaged in the RD&I activities within the organisation in focus. Considering that complexity, multidimensionality and uncertainty are inherent to innovation capacity and performance measurements, fuzzy logic [57] is strongly recommended in this stage, as various managers and collaborators will undoubtedly be involved. By way of illustration, the results of Hájek et al. [41,42] show that the fuzzy logic approach can be successfully used in a structured methodology in the BSC design as an innovation performance measurement system.

The next step in this stage is to calculate the SOIC and SOIP indexes. For this, the managers and collaborators that are engaged in the RD&I activities within the organisation are asked to assess the current SOIC level according to the key innovation indicators associated with the lower BSC perspectives ('Internal Processes' and 'Learning and Growth').

Using the five-point scale shown in Table 5, the SOIC index of the organisation can be calculated by multiplying the ratings assigned by the managers and experts by the relative weights of the key innovation indicators. Thus, the SOIC can be determined by multiplying the current SOIC levels (assessed by the managers and experts) with the relative weights of the key innovation indicators associated with the lower BSC perspectives ('Internal Process' and 'Learning and Growth'). The resulting SOIC can be calculated by summing them up.

Similarly, the SOIP index can also be calculated, but in this case, the relative weights of the key innovation indicators will be those of the upper BSC perspectives ('Market' and 'Sustainability'), and the five-point scale to be adopted is that presented in Table 6.

4. Applicability of Conceptual Model to Innovative Company in Brazilian Electricity Sector

This section presents and discusses the results of an empirical study developed for an innovative company in the Brazilian electricity sector (the Alpha Company (fictitious name)) in 2021, with the aim of demonstrating the applicability of the proposed model in a corporate environment. As a result, the current SOIC and SOIP indexes could be calculated from the assessment of the current achievement level of the SOIC and SOIP according to 23 key innovation indicators to monitor and evaluate the progress of the company's innovation strategy toward sustainability (see Figure 3).

4.1. Empirical Study Proposition and Guiding Questions

This empirical study aims to demonstrate that the conceptual model proposed in Section 3 can be used to effectively measure and evaluate the SOIC and SOIP of established organisations that seek excellence in their sustainability-oriented innovation management systems. Following the protocol suggested by Yin [63], three guiding questions were defined:

- Is it feasible to demonstrate the applicability of the proposed model by developing an empirical study conducted for the Alpha Company with the RD&I manager and technical assistants working in the innovation area of the company?
- What are the key innovation indicators chosen to integrate the analytical network structure to be used during the assessment process?

- What are the company's SOIC and SOIP indexes?

The results of the empirical study developed for the Alpha Company are summarised below.

4.2. Characterisation of Unit of Analysis and Its Organisational and Business Contexts

According to Yin [63], the unit of analysis needs to reflect how the research problem was defined. Thus, focusing on the central research problem, the unit of analysis in this empirical study was defined as the SOIC and SOIP measurement and evaluation based on the conceptual model presented in the previous section.

The Alpha Company is a thermal and hydroelectric generation platform that generates energy for more than 4 million people in Brazil. The company is a development platform for the Alpha Holding Group's new thermal–hydro-generation businesses in Brazil. It operates two plants in different states in the country. With an installed capacity of 827 MW, the first plant supplies 25% of the energy consumed in the metropolitan region of one of the states, serving 2.5 million people.

The second plant began operating in 2019, it has an installed capacity of 401.88 MW and it is responsible for generating approximately 50% of the energy consumed in the other state, serving 1.5 million people. The Alpha Company has been adopting sustainable practices in the operation of both plants, demonstrating how relevant environmental practices are for the company, including emission management, the implementation of monitoring systems for improving the water quality, the implementation of a rainwater reuse project and the construction of a Centre for Environmental Experiences, where the concepts of sustainability and integration have been applied.

One reason that we chose the Alpha Company for this empirical study is that, in its strategic vision, the company states that it intends to be a competitive, profitable and socially responsible company, and to become a benchmark in thermal power generation with a strong identity, appreciated by all stakeholders, and fully integrated into the regions in which it operates. Another important aspect is the company's sustainability policies that have been guiding its operations, including RD&I initiatives that reinforce its commitment to monitor the economic, environmental and social impacts of its activities. In this empirical study, the company's participants believe that the conceptual model proposed here will provide a flexible and robust methodological solution to the complex problem of measuring and evaluating the SOIC and SOIP at the corporate level.

The application of the conceptual model at the Alpha Company rigorously followed all the steps described in Section 3.

4.3. Demonstrating Applicability of Conceptual Model

As described in Section 3 (Item 3.1), the four original BSC perspectives were adapted for application in the context of sustainability-oriented innovation management in general, and within the Alpha Company. During the first interview with the innovation manager, it was found that the company had already established strategic innovation goals as part of its strategic planning. However, the company had not yet adopted the BSC approach as a strategic management system. Following this, the authors proposed a virtual kickoff meeting with the innovation manager and team to explain the objectives and conceptual model, and to classify the company's strategic innovation goals (SIGs) into a 'strategy map' based on the BSC framework [17]. The results of this first meeting are schematically represented in Figure 2.

After classifying the SIGs according to the four BSC perspectives, the RD&I manager and team were asked to define the key innovation indicators (KIIs) related to the seven SIGs in a second virtual session. This information was crucial to the integration of the analytical network structure based on the BSC framework. Prior to this meeting, the authors sent a list of KIIs for the measurement and evaluation of the SOIC and SOIP levels of established organisations (see Appendix C, Table A4).

Once the strategic innovation goals associated with the four BSC perspectives were established, the respective key innovation indicators were ranked and selected by employing the TOPSIS method described in Section 3 (Item 3.1). As mentioned before, the best alternatives are those with higher closeness coefficient (CCi) values, and therefore, they should be chosen because they are closer to the PIS. This procedure should be performed for each BSC perspective. All the formulas and parameters used in this procedure can be found in [54].

Tables 7–13 show the selected KIIs that integrate the Alpha Company's system for monitoring and evaluating its SOIC and SOIP levels.

Table 7. Euclidian distances, closeness coefficients and ranking of innovation indicators associated with strategic innovation goal 'Innovation-based economic sustainability' (SIG11).

Ref.	Innovation Indicator	Euclidian Distances		Closeness Coefficient (CCi)	Final Ranking
		D+	D−		
I111	Number of commercialised patents and products	0.06	0.14	0.72	3rd
I112	ROI of realised patents and products	0.14	0.06	0.31	5th
I113	Royalties of commercialised patents and products per year	0.04	0.15	0.78	2nd
I114	Net cash generated by commercialised patents and products per year	0.00	0.15	1.00	1st
I115	Budget spent on research, development and innovation (RD&I)	0.08	0.11	0.57	4th
I116	Share of RD&I budget from total company budget	0.08	0.11	0.57	4th

Table 8. Euclidian distances, closeness coefficients and ranking of innovation indicators associated with strategic innovation goal 'Innovation-based environmental sustainability' (SIG12).

Ref.	Innovation Indicator	Euclidian Distances		Closeness Coefficient (CCi)	Final Ranking
		D+	D−		
I121	Number of projects with environmental relevance to organisation's region per year	0.06	0.14	0.72	3rd
I122	Number of innovative solutions for circular economy per year	0.14	0.06	0.31	5th
I123	Improvement rate in use of alternative energy/material due to ecoinnovations	0.04	0.15	0.78	2nd
I124	Number of innovative solutions to mitigate environmental risk per year	0.00	0.15	1.00	1st
I125	Reduction rate of adverse event impact due to ecoinnovations	0.08	0.11	0.57	4th

Table 9. Euclidian distances, closeness coefficients and ranking of innovation indicators associated with strategic innovation goal 'Innovation-based social sustainability' (SIG13).

Ref.	Innovation Indicator	Euclidian Distances		Closeness Coefficient (CCi)	Final Ranking
		D+	D−		
I131	Number of key internal and external stakeholders integrated into R&D projects to improve sustainability concerns in value chains	0.06	0.12	0.65	2nd
I132	Number of innovations with social impacts	0.00	0.16	1.00	1st
I133	Involvement of local SMEs in innovations with impacts on supply chain	0.09	0.09	0.49	5th
I134	Improvement in occupational rate of organisation's region	0.12	0.06	0.35	6th
I135	Innovative startup birth rate	0.07	0.13	0.65	2nd
I136	Number of knowledge transfer sessions (KTSs)	0.12	0.06	0.35	6th
I137	Number of employees dedicated to external relationships in RD&I projects	0.12	0.06	0.35	6th
I138	Number of local alliances dedicated to RD&I projects	0.11	0.11	0.50	3rd

Table 10. Euclidian distances, closeness coefficients and ranking of innovation indicators associated with strategic innovation goal 'Higher competitiveness and new markets' (SIG21).

Ref.	Innovation Indicator	Euclidian Distances		Closeness Coefficient (CCi)	Final Ranking
		D+	D−		
I211	Number of new or significantly improved products (goods or services) introduced into market per year	0.00	0.10	1.00	1st
I212	Number of innovative businesses/new venture startups	0.08	0.06	0.40	3rd
I213	Number of firms adopting commercialised patents and products	0.00	0.10	1.00	1st
I214	Market share of firms adopting commercialised patents and products	0.05	0.09	0.63	2nd
I215	New product introduction into market versus competition	0.09	0.05	0.37	4th
I216	Annual spending for market investigations aimed at generating technological innovation	0.09	0.04	0.31	5th

Table 11. Euclidian distances, closeness coefficients and ranking of innovation indicators associated with strategic innovation goal 'Innovation management system improvement' (SIG31).

Ref.	Innovation Indicator	Euclidian Distances		Closeness Coefficient (CCi)	Final Ranking
		D+	D−		
I311	Number of projects that developed new models, methods and/or standards to improve RD&I practices	0.05	0.09	0.63	3rd
I312	Number of new business models or frameworks developed and implemented through collaborative projects	0.04	0.09	0.69	2nd
I313	Percentage of RD&I projects abandoned after a certain degree of completion	0.06	0.08	0.55	4th
I314	Percentage of successful RD&I projects aligned to innovation strategy toward sustainability	0.00	0.10	1.00	1st
I315	Time dedicated to analysis of reasons for failure of previous projects	0.09	0.04	0.31	5th
I316	Percentage of RD&I activities formally documented	0.09	0.04	0.31	5th
I317	Percentage of RD&I projects respecting established deadlines	0.09	0.04	0.31	5th

Table 12. Euclidian distances, closeness coefficients and ranking of innovation indicators associated with strategic innovation goal 'Human and structural capital enhancement' (SIG41).

Ref.	Innovation Indicator	Euclidian Distances		Closeness Coefficient (CCi)	Final Ranking
		D+	D−		
I411	Number of joint training programs for researchers and employees	0.11	0.06	0.37	5th
I412	Improvement in employee and researcher satisfaction	0.11	0.06	0.34	6th
I413	Number of meetings among partners	0.11	0.06	0.37	5th
I414	Number of publications in scientific journals or conferences per year	0.04	0.12	0.76	2nd
I415	Number of new intangibles per year (patents, licenses, copyrights, among others) per year	0.00	0.14	1.00	1st
I416	Number of information systems implemented for sharing RD&I data	0.07	0.09	0.57	3rd
I417	Number of employees devoted to RD&I activities/total of employees per year	0.09	0.07	0.46	4th
I418	Percentage of time spent by managers on RD&I activities compared with other business tasks	0.09	0.07	0.46	4th

Table 13. Euclidian distances, closeness coefficients and ranking of innovation indicators associated with strategic innovation goal 'Relational capital enhancement' (SIG42).

Ref.	Innovation Indicator	Euclidian Distances		Closeness Coefficient (CCi)	Final Ranking
		D+	D−		
I421	Social engagement in organisation's region	0.15	0.04	0.20	7th
I422	Number of new cocreated skills and knowledge per year through RD&I cooperation	0.00	0.16	1.00	1st
I423	Use of internal and external knowledge and information sources	0.12	0.10	0.45	4th
I424	Transfer rate of new knowledge and technology into product development (goods or services)	0.10	0.07	0.43	5th
I425	Number of newly created innovative opportunities with customers, suppliers or partners	0.05	0.14	0.73	2nd
I426	Number of ideas generated with customers, suppliers or partners	0.12	0.07	0.37	6th
I427	Number of projects funded by external organisations per year	0.07	0.11	0.60	3rd

4.3.1. Stage 1: Determination of an Analytic Network Structure based on BSC Framework

Once key innovation indicators are ranked and selected (Tables 7–13), an analytic network structure for measuring and evaluating the SOIC and SOIP levels of Alpha Company can be represented, as shown in Figure 3.
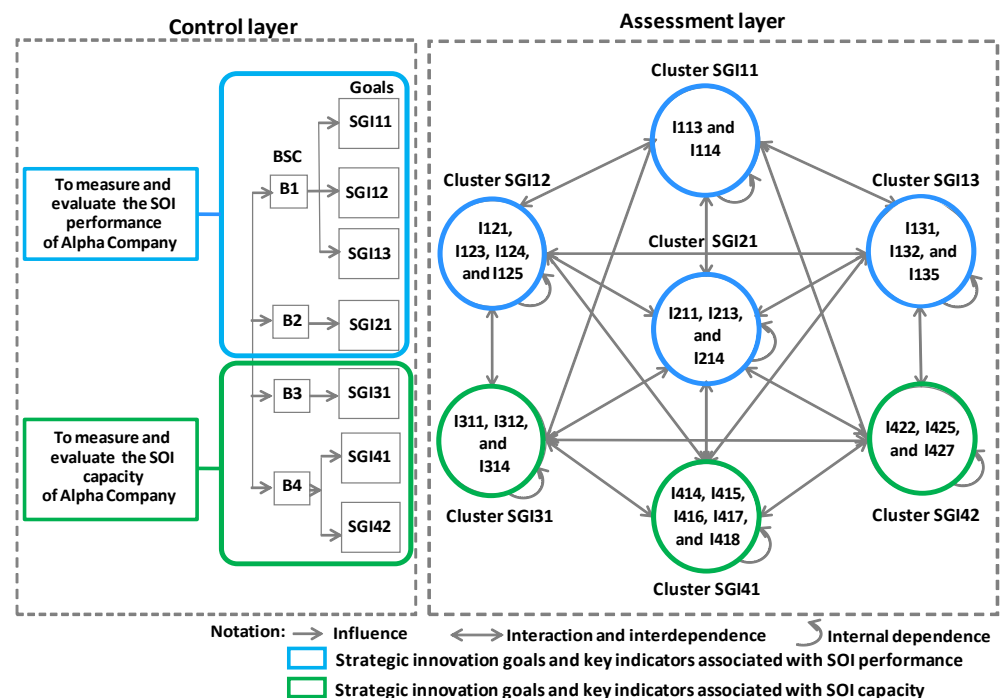
Figure 3. Analytic network structure for measuring and evaluating SOIC and SOIP levels of Alpha Company.

In Figure 3, the control layer consists of seven strategic innovation goals (from SIG11 to SIG13, SIG21, SIG31, SIG41 and SIG42). In turn, the assessment layer comprises 23 key innovation indicators (KIIs) that are organised into seven clusters that correspond to the mentioned strategic innovation goals. The clusters in green are associated with the SOIC, while the clusters in blue correspond to the KIIs used for measuring and evaluating the SOIP level of the Alpha Company.

Table 14 details the control- and assessment-layer elements that integrate the analytical network structure that corresponds to the visual representation presented in Figure 3.

Table 14. Analytical network structure for measuring and evaluating SOIC and SOIP levels of Alpha Company.

Target Layer (A)	Control Layer		Assessment Layer
	BSC Perspective (B)	Strategic Innovation Goal (SIG)_	Key Innovation Indicator (KII)
To measure and evaluate SOIP of Alpha Company	Sustainability (B1)	Innovation-based economic sustainability (SIG11)	I113—Royalties of commercialised patents and products per year
			I114—Net cash generated by commercialised patents and products per year
		Innovation-based environmental sustainability (SIG12)	I121—Number of projects with environmental relevance to organisation's region per year
			I123—Improvement rate in use of alternative energy/material due to ecoinnovations
			I124—Number of innovative solutions to mitigate environmental risk per year
			I125—Reduction rate of adverse event impact due to ecoinnovations
		Innovation-based social sustainability (SIG13)	I131—Number of projects that developed new models, methods and/or standards to improve RD&I practices
			I132—Number of new business models or frameworks developed and implemented through collaborative projects
			I135—Innovative startup birth rate
	Market (B2)	Higher competitiveness and new markets (SIG21)	I211—Number of new or significantly improved products (goods or services) introduced into market per year
			I213—Number of innovative businesses/new venture startups per year
			I214—Number of firms adopting commercialised patents and products
To measure and evaluate SOIC of Alpha Company	Internal Processes (B3)	Innovation management system improvement (SIG31)	I311—Number of projects that developed new models, methods and/or standards to improve RD&I practices
			I312—Number of new business models or frameworks developed and implemented through collaborative projects
			I314—Percentage of successful RD&I projects aligned to innovation strategy toward sustainability
	Learning and Growth (B4)	Human and structural capital enhancement (SIG41)	I414—Number of publications in scientific journals or conferences per year
			I415—Number of new intangibles per year (patents, licenses, copyrights, among others) per year
			I416—Number of information systems implemented for sharing RD&I data
			I417—Number of employees devoted to RD&I activities/total of employees per year
			I418—Percentage of time spent by managers on RD&I activities compared with other business tasks
		Relational capital enhancement (SIG42)	I422—Number of new cocreated skills and knowledge through RD&I cooperation per year
			I425—Number of newly created innovative opportunities with customers, suppliers or partners
			I427- Number of projects funded by external organisations per year

Following the procedure described in Section 3.1, an interfactorial dominance matrix was built in a consensus-building session (see Table 15).

Table 15. Interfactorial dominance matrix: empirical study conducted on Alpha Company.

Interfactorial Dominance Matrix		SIG11		SIG12				SIG13			SIG21			SIG31			SIG41					SIG42		
		I113	I114	I121	I123	I124	I125	I131	I132	I135	I211	I213	I214	I311	I312	I314	I414	I415	I416	I417	I418	I422	I425	I427
SIG11—Innovation-based economic sustainability	I113	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1
	I114	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1
SIG12—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
	I123	0	0	1	0	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	0	1	1	0
	I124	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1
	I125	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SIG13—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
	I135	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1
SIG21—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
	I213	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
	I214	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1
SIG31—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
	I314	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
SIG41—Human and structural capital enhancement	I414	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1
	I415	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1
	I416	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1
	I417	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1
	I418	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1
SIG41—Relational capital enhancement	I422	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0
	I425	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1
	I427	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	1	1	1	0	0	0

Likewise, a control hierarchy matrix concerning the interactions among the strategic innovation goals (the clusters in the network structure) was formed by the seven SIGs listed in Table 14 (i.e., a 7 × 7 matrix). If at least one element in a cluster influences one element in another cluster, then 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, then this cell is '0'.

As shown in Table 16, all the clusters influenced the others, which confirmed that the strategic innovation goals formed a network, and that the interdependencies between them could be objectively evidenced.

Table 16. Control hierarchy matrix: empirical study conducted on Alpha Company.

Control Hierarchy Matrix	SIG11	SIG12	SIG13	SIG21	SIG31	SIG41	SIG42
SIG11—Innovation-based economic sustainability	0	1	1	1	1	1	1
SIG12—Innovation-based environmental sustainability	1	0	1	1	1	1	1
SIG13—Innovation-based social sustainability	1	1	0	1	1	1	1
SIG21—Higher competitiveness and new markets	1	1	1	0	1	1	1
SIG31—Innovation management system improvement	1	1	1	1	0	1	1
SIG41—Human and structural capital enhancement	1	1	1	1	1	0	1
SIG42—Relational capital enhancement	1	1	1	1	1	1	0

4.3.2. Stage 2: Design and Pretesting of Questionnaire for Pairwise Comparisons of Elements of Analytical Network Structure

The questionnaire design for the pairwise comparisons was based on the results of the interfactorial dominance matrix and control hierarchy matrix. The questionnaire was pretested with a group of six academic researchers who specialised in innovation management, to be further applied for the Alpha Company during Stage 3 (see Section 4, Item 4.3).

4.3.3. Stage 3: Determination of Importance Weights of Assessment Elements

For determining the importance weights of the 23 assessment elements and seven clusters, Saaty's nine-point scale (Table 4) was used for the pairwise comparisons conducted by the innovation manager and two technical assistants of the Alpha Company. In this stage, an unweighted supermatrix is built, as shown in Table 17.

For building the unweighted supermatrix, they used the questionnaire pretested in Stage 2, and they followed the general instructions provided by the authors. In this stage, Super Decisions® 2.8 was used for calculating the unweighted and weighted supermatrixes [58]. After consolidating the 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. Following Item 3.3, the value corresponding to the priority associated with a specific cluster determines the importance of the cluster's elements on which it acts (in the unweighted supermatrix). Thus, 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 compared with all the others to which it was connected. A 7 × 7 matrix was built that corresponded to the network clusters (i.e., the seven strategic innovation goals). Table 18 shows the resulting weights of the network clusters. A sensitivity analysis procedure was also conducted considering all the importance weights of the SIGs equally, and the results are shown in the right column of Table 18.

In sequence, a weighted supermatrix could be obtained, as shown in Table 19.

Table 17. Unweighted supermatrix: empirical study conducted on Alpha Company.

	I113	I114	I121	I123	I124	I125	I131	I132	I135	I211	I213	I214	I311	I312	I314	I414	I415	I416	I417	I418	I422	I425	I427
I113	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
I114	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
I121	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
I123	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
I124	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
I125	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
I131	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
I132	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
I135	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
I211	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
I213	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
I214	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
I311	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
I312	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
I314	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
I414	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
I415	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
I416	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
I417	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
I418	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
I422	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
I425	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
I427	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

Table 18. Importance weights of network clusters: empirical study conducted on Alpha Company.

Strategic Innovation Goals: Network Clusters	Importance Weight	Importance Weight (Sensitivity Analysis)
SIG11—Innovation-based economic sustainability	0.06395	0.14286
SIG12—Innovation-based environmental sustainability	0.06395	0.14286
SIG13—Innovation-based social sustainability	0.06395	0.14286
SIG21—Higher competitiveness and new markets due to innovation	0.11171	0.14286
SIG31—Innovation management system improvement	0.17199	0.14286
SIG41—Human and structural capital enhancement	0.25618	0.14286
SIG42—Relational capital enhancement	0.26828	0.14286

Table 19. Weighted supermatrix: empirical study conducted on Alpha Company.

	I113	I114	I121	I123	I124	I125	I131	I132	I135	I211	I213	I214	I311	I312	I314	I414	I415	I416	I417	I418	I422	I425	I427
I113	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
I114	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
I121	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
I123	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
I124	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
I125	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
I131	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
I132	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
I135	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
I211	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
I213	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
I214	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
I311	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

Table 19. *Cont.*

	I113	I114	I121	I123	I124	I125	I131	I132	I135	I211	I213	I214	I311	I312	I314	I414	I415	I416	I417	I418	I422	I425	I427
I312	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
I314	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
I414	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
I415	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
I416	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
I417	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
I418	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
I422	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
I425	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
I427	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

4.3.4. Stage 4: Calculation of Limit Supermatrix and Resulting Weights of Network Element Framework

Table 20 shows the limit supermatrix calculated with the support of Super Decisions® software.

Table 20. Limit supermatrix: empirical study conducted on Alpha Company.

	I113	I114	I121	I123	I124	I125	I131	I132	I135	I211	I213	I214	I311	I312	I314	I414	I415	I416	I417	I418	I422	I425	I427
I113	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
I114	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	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	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I123	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
I124	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
I125	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
I135	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
I213	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
I214	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
I314	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
I414	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
I415	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
I416	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
I417	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
I418	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
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
I425	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
I427	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

As mentioned in Item 3.4, with the support of Super Decisions® software [59], the authors used a computations-limit matrix to calculate the limit supermatrix, which is derived from performing the power operation on the weighted supermatrix. Its weighted value tends towards stability.

Finally, the resulting weights of the 23 key innovation indicators (assessment elements) could be calculated, as shown in Table 21. As mentioned before, a sensitivity analysis procedure was conducted to test the robustness of the model when all the SIG importance weights are equal. The narrow difference between the indicator weights with or without the sensitivity test can be seen.

Table 21. Importance weights of assessment elements: empirical study conducted on Alpha Company.

SOIP Indicators	Weight	Weight (Sensitivity Analysis)
I113—Royalties of commercialised patents and products per year	0.027	0.029
I114—Net cash generated by commercialised patents and products per year	0.025	0.025
I121—Number of projects with environmental relevance to organisation's region per year	0.001	0.001
I123—Improvement rate in use of alternative energy/material due to ecoinnovations	0.015	0.015
I124—Number of innovative solutions to mitigate environmental risk per year	0.045	0.050
I125—Reduction rate of adverse event impact due to ecoinnovations	0.002	0.002
I131—Number of projects that developed new models, methods and/or standards to improve RD&I practices	0.006	0.006
I132—Number of new business models or frameworks developed and implemented through collaborative projects	0.034	0.035
I135—Innovative startup birth rate	0.030	0.032
I211—Number of new or significantly improved products (goods or services) introduced into market per year	0.042	0.043
I213—Number of innovative businesses/new venture startups per year	0.043	0.043
I214—Number of firms adopting commercialised patents and products	0.036	0.037
SOIP (Total Weight)	**0.305**	0.309
SOIC Indicators	Weight	Weight (Sensitivity Analysis)
I311—Number of projects that developed new models, methods and/or standards to improve RD&I practices	0.062	0.062
I312—Number of new business models or frameworks developed and implemented through collaborative projects	0.057	0.056
I314—Percentage of successful RD&I projects aligned to innovation strategy toward sustainability	0.067	0.067
I414—Number of publications in scientific journals or conferences per year	0.074	0.072
I415—Number of new intangibles per year (patents, licenses, copyrights, etc.) per year	0.073	0.071
I416—Number of information systems implemented for sharing RD&I data	0.030	0.029
I417—Number of employees devoted to RD&I activities/total of employees per year	0.066	0.064
I418—Percentage of time spent by managers on RD&I activities compared with other business tasks	0.033	0.033
I422—Number of new cocreated skills and knowledge through RD&I cooperation per year	0.109	0.106
I425—Number of newly created innovative opportunities with customers, suppliers or partners	0.109	0.106
I427—Number of projects funded by external organisations per year	0.015	0.015
SOIC Indicators (Total Weight)	**0.695**	0.699

The results presented here demonstrate that, from the perception of the participants, strategic innovation goal SIG31 concerning the "Internal Process" (B3), and goals SIG41 and SIG42 associated with the "Learning and Growth" (B4) perspective, have the most significant influences in the whole innovation management system of the company. The weights of the SOIC key indicators correspond to 69.50%, while the SOIC key innovation indicators correspond to 30.50%.

Both perspectives (B3 and B4) help the Alpha Company understand the efficiency and effectiveness of its internal processes that support RD&I activities and projects. Particularly, the weight assigned to the key innovation indicators of the "Learning and Growth" perspective expresses the belief that humans are the most important asset of the company's

innovation capacity to improve the business performance. This perspective considers the degree to which the Alpha Company can evolve and improve the way it pursues its strategic innovation goal (SIG) achievement.

As can be observed in Table 21, the key indicators I422 (number of new cocreated skills and knowledge through RD&I cooperation per year) and I425 (number of newly created innovative opportunities with customers, suppliers or partners) achieved the highest positions in the ranking.

These results can be explained by the fact that the Alpha Company has adopted the open innovation model, the central pillar of which is a knowledge network with customers, suppliers, universities and other institutional actors. Therefore, this company considers RD&I cooperation to be an essential dynamic capacity for enhancing its innovation management system to achieve its sustainability vision, as discussed in Item 4.2. Another argument is that the Brazilian Electrical Energy Regulatory Agency (the Portuguese acronym is ANEEL) created an institutional Research and Development Program to encourage cooperative research among firms, universities and research centres for innovation to face the technological challenges of the electric sector in Brazil. Accordingly, concessionary, permissionary or authorised electric energy distribution, transmission and generation companies must annually apply a minimum percentage of their net operating revenues to this R&D Program. Thus, the Alpha Company's RD&I portfolio management is preponderantly based on cooperative research that involves local universities, research centres and other institutional actors.

4.3.5. Stage 5: Determination of Five-Point Scales for Measuring SOIC and SOIP

In this stage, the two five-point scales shown in Tables 5 and 6 were used, as reported in Item 4.3.6. The scales range from Level 5 (high SOIC or low SOIP) to Level 1 (low SOIC or SOIP).

4.3.6. Stage 6: Application of Self-Assessment Instrument and Calculation of SOIC and SOIP Indexes

Based on the analytical network structure detailed in Table 14, the self-assessment instrument was designed to measure the company's status concerning each assessment element. A pretest with a group of six academic researchers who specialised in innovation management was conducted in the second semester of 2020, before being administered to the innovation manager and two technical assistants at the Alpha Company. For making the judgments in the consensus-building meeting, they used the five-point scales proposed in Stage 5 of the model (see Tables 5 and 6).

First, the participants were asked to evaluate the current SOIC levels regarding the key innovation indicators associated with the strategic innovation goals of the lower BSC perspectives ('Internal Process' (B3) and 'Learning and Growth' (B4)). Accordingly, they used the five-point scale shown in Table 5.

Hence, the SOIC level of the Alpha Company could be calculated by multiplying the current innovation capacity levels (from 1 to 5) with the relative weights of the 11 key innovation indicators associated with the lower BSC perspectives (B3 and B4). Then, the resulting SOIC level could be calculated by summing them up.

Table 22 shows how the SOIC of the Alpha Company was calculated, considering the weights assigned to each assessment factor.

Table 22. Calculation of SOIC level of Alpha Company.

Assessment Factors Associated with 'Learning and Growth' and 'Internal Processes' Perspectives	Indicator Weight	Current SOIC	Innovation Capacity
I311—Number of projects that developed new models, methods and/or standards to improve RD&I practices	0.062	3	0.185
I312—Number of new business models or frameworks developed and implemented through collaborative projects	0.057	5	0.284
I314—Percentage of successful RD&I projects aligned to innovation strategy toward sustainability	0.067	4	0.269
I414—Number of publications in scientific journals or conferences per year	0.074	2	0.148
I415—Number of new intangibles per year (patents, licenses, copyrights, etc.) per year	0.073	3	0.219
I416—Number of information systems implemented for sharing RD&I data	0.030	1	0.030
I417—Number of employees devoted to RD&I activities/total of employees per year	0.066	2	0.132
I418—Percentage of time spent by managers on RD&I activities compared with other business tasks	0.033	1	0.033
I422—Number of new cocreated skills and knowledge through RD&I cooperation per year	0.109	4	0.435
I425—Number of newly created innovative opportunities with customers, suppliers or partners	0.109	4	0.435
I427—Number of projects funded by external organisations per year	0.015	5	0.077

The results shown in Table 22 were framed on a standard scale with the aim of obtaining the relative position of the company regarding its SOIC measured by the key innovation indicators associated with the following strategic goals: 'Innovation management system improvement' (SIG31), 'Human and structural capital enhancement' (SIG41) and 'Relational capital enhancement' (SIG42).

From the indicator weights, it was possible to normalise the scales for the classification of the SOIC levels, as follows:

$$\text{Min (SOIC)} = \frac{1 * \sum_{i=I311}^{i=I427} \text{Indicator weight}}{\sum_{i=I311}^{i=I427} \text{Indicator weight}} = 1 \tag{1}$$

$$\text{Max(SOIC)} = \frac{5 * \sum_{i=I311}^{i=I427} \text{Indicator weight}}{\sum_{i=I311}^{i=I427} \text{Indicator weight}} = 5 \tag{2}$$

Five ranges between the Min (SOIC) and Max (SOIC) values were established to normalise the results shown in Table 20 according to the SOIC levels defined on the five-point scale. Accordingly, Table 23 refers to the normalised SOIC ranges associated with the respective SOIC levels.

Following Equation (3), the SOIC index of the Alpha Company could be calculated. The index indicated that the company is situated at the medium innovation capacity level.

$$\text{SOIC index} = \frac{\sum_{i=I311}^{i=I427} \text{Indicator weight} * \text{current SOIC}}{\sum_{i=I311}^{i=I427} \text{Indicator weight}} = \frac{2.247}{0.695} = 3.233 \tag{3}$$

Figure 4 represents the current SOIC index of the Alpha Company in dashboard format.

Table 23. Ranges of SOIC levels associated with five-point scale (cf. Table 5).

SOIC Level	Description	SOIC Range	Normalised SOIC Range
Low (L)	Low degree of achievement of targets associated with KIIs linked to SIGs from 'Internal Processes' and 'Learning and Growth' perspectives.	1.0–1.8	0.695–1.251
Low–medium (L.M.)	Low–medium degree of achievement of targets associated with KIIs linked to SIGs from 'Internal Processes' and 'Learning and Growth' perspectives.	1.8–2.6	1.251–1.807
Medium level (M)	Medium degree of achievement of targets associated with innovation indicators linked to strategic innovation objectives from 'Internal Processes' and 'Learning and Growth' perspectives.	2.6–3.4	1.807–2.363
Medium–high (M.H.)	Medium–high degree of achievement of targets associated with KIIs linked to SIGs from 'Internal Processes' and 'Learning and Growth' perspectives.	3.4–4.2	2.365–2.919
High (H)	High degree of achievement of targets associated with KIIs linked to SIGs from 'Internal Processes' and 'Learning and Growth' perspectives.	4.2–5.0	2.921–3.475
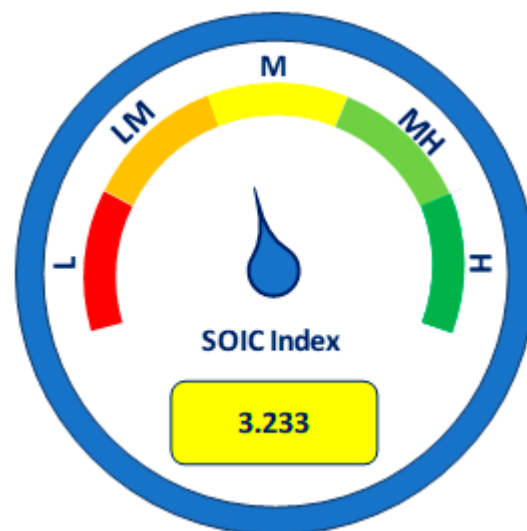
Figure 4. Current SOIC index of Alpha Company in dashboard format.

Similarly, the SOIP of the Alpha Company could be calculated, but in this case, the relative weights of the 12 key innovation indicators were associated with the upper BSC perspectives ('Sustainability' (B1) and 'Market' (B2)).

Table 24 shows how the SOIP of the Alpha Company was measured, considering the weights assigned to each assessment factor (second column from left).

The results were framed on a standard scale to obtain the relative position of the company regarding its SOIP measured by the key innovation indicators associated with the following strategic goals: 'Innovation-based economic sustainability' (SIG11), 'Innovation-based environmental sustainability' (SIG12), 'Innovation-based social sustainability' (SIG13) and 'Higher competitiveness and new markets' (SIG21). From the indicator weights (second column from left), it was possible to normalise the scales for the classification of the SOIP levels, following Equations (4)–(6):

$$\text{Min (SOIP)} = \frac{1 * \sum_{i=I113}^{i=I214} \text{Indicator weight}}{\sum_{i=I113}^{i=I213} \text{Indicator weight}} = 1 \tag{4}$$

$$\text{Max(SOIP)} = \frac{5 * \sum_{i=I113}^{i=I214} \text{Indicator weight}}{\sum_{i=I113}^{i=I214} \text{Indicator weight}} = 5 \tag{5}$$

Table 24. Calculation of SOI performance of Alpha Company.

Assessment Factors Associated with 'Market' and 'Sustainability' Perspectives	Indicator Weight	Current SOIP	Innovation Performance
I113—Royalties of commercialised patents and products	0.027	1	0.027
I114—Net cash generated by commercialised patents and products	0.025	1	0.025
I121—Number of projects with environmental relevance to organisation's region	0.001	4	0.004
I123—Improvement in use of alternative energy/material due to ecoinnovations	0.015	3	0.045
I124—Number of innovative solutions to mitigate risk (operational risk, compliance risk, environmental risk)	0.045	3	0.135
I125—Reduction in adverse event impact due to ecoinnovations	0.002	2	0.004
I131—Number of key internal and external stakeholders integrated into R&D projects to improve sustainability concerns in value chains	0.006	4	0.024
I132—Number of innovations with social impacts	0.033	5	0.165
I135—Innovative startup birth rate	0.030	2	0.060
I211—Number of new or significantly improved products (goods or services) introduced into market	0.042	3	0.126
I213—Number of firms adopting commercialised patents and products	0.043	3	0.129
I214—Market share of firms adopting commercialised patents and products	0.036	3	0.108

Between the Min (SOIP) and Max (SOIP) values, five ranges were established to fit the results according to the innovation performance levels defined on the five-point scale (Table 25).

Table 25. Ranges of SOIP levels associated with five-point scale (cf. Table 6).

SOIP Level	Description	SOIP Range	Normalised Range
1. Low (L)	Low degree of achievement of targets associated with KIIs linked to SIGs from 'Market' and 'Sustainability' BSC perspectives.	1.0–1.8	0.305–0.549
2. Low–medium (L.M.)	Low–medium degree of achievement of targets associated with KIIs linked to SIGs from 'Market' and 'Sustainability' BSC perspectives.	1.8–2.6	0.549–0.793
3. Medium (M)	Medium degree of achievement of targets associated with KIIs linked to SIGs from 'Market' and 'Sustainability' BSC perspectives.	2.6–3.4	0.793–1.037
4. Medium–high (M.H.)	Medium–high degree of achievement of targets associated with KIIs linked to SIGs from 'Market' and 'Sustainability' BSC perspectives.	3.4–4.2	1.037–1.281
5. High (H)	High degree of achievement of targets associated with KIIs linked to SIGs from 'Market' and 'Sustainability' BSC perspectives.	4.2–5.0	1.281–1.525

Following Equation (6), the SOIP index of the Alpha Company could be calculated. The index indicated that the company is situated in the medium innovation performance range.

$$\text{SOIP index} = \frac{\sum_{i=I113}^{i=I214} \text{Indicator weight} * \text{current SOIP}}{\sum_{i=I113}^{i=I214} \text{Indicator weight}} = \frac{0.850}{0.305} = 2.793 \quad (6)$$

Figure 5 represents the current SOIP index of the Alpha Company in dashboard format. The SOIC and SOIP indexes graphically represented in the two dashboards (Figures 4 and 5, respectively) were calculated in line with the weights assigned to each assessment element in individual cases. Both indexes can help the managers in the Alpha Company to propose and implement strategic RD&I initiatives that are addressed to boost the company's SOIC level, and consequently, its SOIP level.
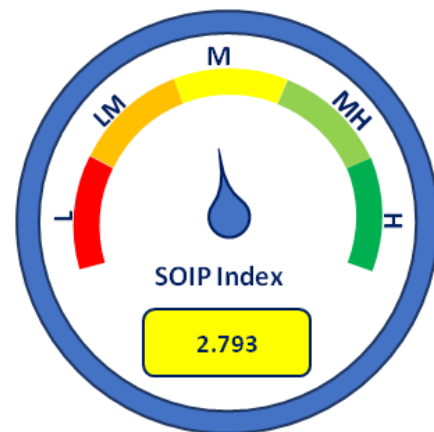
Figure 5. Current SOIP index of Alpha Company in dashboard format.

5. Discussion

As stated in the introductory section, in the last decades, researchers and consulting firms have designed several multidimensional models for measuring and evaluating the innovation capacity and performance, which have been adopted by established innovative organisations worldwide. Most of these models combine financial and nonfinancial indicators to measure the organisation's tangible and intangible assets and value creation. As mentioned in the introductory section, some outstanding examples are the BSC [16–18] and performance prism frameworks [19,20]. However, research on the measurement and evaluation models designed for sustainability-oriented innovation management has remained underexplored by researchers and practitioners. Moreover, the 'strategy map' representation presented by Kaplan and Norton [18] considers the innovation process as a linear and separately identifiable construct.

Particularly concerning the mentioned issues, in the adapted BSC framework proposed in this paper, the SOIC and SOIP are seen more holistically as parts of an organisation's 'strategy map', which is schematically represented in Figure 2. The original 'Financial' perspective was replaced by the 'Sustainability' perspective, and the 'Market', 'Internal Processes' and 'Learning and Growth' perspectives were maintained. The following principles guided the model development: a multidimensional structure, stakeholder goal orientation, interdependence and feedback loop analyses, innovation process orientation and easy implementation and use.

Concerning the first guiding principle, a multidimensional orientation effectively accommodated a well-balanced combination of the financial and nonfinancial measures in the modelling phase of this research. In this regard, several researchers agree that the multidimensional structure of the BSC framework provides a good foundation for designing a conceptual model for measuring and evaluating the innovation capacity and performance [31–42]. Thus, the proposed model is in line with previous studies in which researchers adopted a methodological approach based on the original BSC framework but adapted it for addressing the sustainability-oriented innovation management issues not covered by them.

The second guiding principle—'Innovation process orientation'—was a strong focus in the modelling phase because we consider it essential for innovative organisations to understand the role of process-oriented thinking and working in the innovation-driven economy. It may be worth mentioning here that the focus of the original 'Internal Processes' perspective in the BSC framework [16–18] is limited to those processes that affect either the customer value proposition or efficiency improvement, both of which lead to financial benefits. Thus, most of the previous works based entirely on the BSC framework do not adequately fulfil this second guiding principle, despite there being instances of performance measurement for R&D and new product development discussed in [21–30], which advocate an R&D process or lifecycle-based innovation performance measurement.

An innovation capacity and performance measurement model should effectively address the achievement of the organisation's strategic vision, which is aligned to multiple stakeholder interests, such as those of shareholders, employees, customers, suppliers, regulators and society. This was the third guiding principle for the modelling phase. Kaplan and Norton [16–18] posit that the BSC framework can effectively address stakeholder needs to deal with stakeholder alignment and business strategy formulation and implementation. Here, the conceptual model was designed to offer an increased opportunity to address diverse stakeholder groups, and particularly regarding the SIGs and KIIs associated with the 'Learning and Growth' perspective. For example, three of the key innovation indicators selected in the empirical phase of this work, which express the stakeholder engagement in different stages of the innovation process, can be used to systematically monitor the implementation of RD&I initiatives to achieve the respective targets. They are I422 (number of new cocreated skills and knowledge through RD&I cooperation per year), I425 (number of newly created innovative opportunities with customers, suppliers or partners) and I427 (number of projects funded by external organisations per year).

Regarding the fourth guiding principle, the proposed model considers the interdependencies among the BSC perspectives, strategic innovation goals (SIGs) and KIIs by using the ANP method so that they are logically related to one another, and so that importance weights can be assigned to all the assessment elements of the conceptual model. In fact, this methodological orientation enables organisations to determine the value of the various RD&I activities performed by relating them to definite outcomes. The interdependencies can be effectively represented in a unique 'strategy map' of the organisation, which shows the linkages between the assessment elements (KIIs) and SIGs within each BSC perspective.

The last guiding principle refers to ease of use and implementation. In this regard, the conceptual model provides a notable advantage because organisations that already use BSC frameworks will find it easier to select and correlate the key innovation indicators (KIIs) with their key performance indicators (KPIs). Following [34], it was assumed that at the organisational level, a BSC framework can be defined based on the organisation's vision and business strategy so that the relevant strategic innovation goals (SIGs) can be cascaded down. Furthermore, in the modelling phase, the SIGs should be linked to other strategic objectives across the BSC perspectives, and namely the 'Sustainability', 'Market', 'Internal Processes' and 'Learning and Growth' perspectives, as described in Section 3.

As mentioned in the introductory section, considerable research has been dedicated to developing and applying models for measuring and evaluating the innovation capacity and performance based on adaptations of the original BSC framework [21–42]. However, notwithstanding these efforts, two research gaps could be identified. The first gap refers to using a multicriteria approach in the BSC models for analysing the interdependencies and feedback loops among the SIGS and KIIs. No previous model for measuring and evaluating the innovation capacity and performance levels of established organisations has addressed sustainability-oriented innovation management while adhering to the abovementioned guiding principles [34]. Thus, a critical issue addressed in this work is how to apply and combine multicriteria decision-making (MCDM) methods to provide consistent strategic frameworks for evidence-based innovation management decisions from a systemic and sustainability-oriented perspective.

6. Conclusions

In this paper, an attempt was made to present a conceptual model for measuring and evaluating the sustainability-oriented innovation capacity (SOIC) and performance (SOIP) of established organisations, the development of which was guided by the following principles: a multidimensional structure, stakeholder goal orientation, interdependence and feedback loop analyses, innovation process orientation and ease of use and implementation. From the findings summarised in Sections 3 and 4 and discussed in Section 5, it is possible to conclude that the general objective of this research was achieved.

Previous studies on innovation capacity and performance measurement published between 1992 and 2022 were reviewed, with a focus mainly on the methodological issues. One initial conclusion is that, among the reviewed studies, 22 adopted the BSC approach [21–42]. Thus, this finding guided the choice of the BSC framework as the basis for the conceptual model focus of this research.

An in-depth analysis of the 22 studies revealed a research gap regarding the use of a multicriteria decision-making approach that implements an analytical network structure and allows for interdependence and feedback loop analyses among the strategic innovation goals (SIGs) and key innovation indicators (KIIs) for evaluating the SOIC and SOIP levels of established organisations. Thus, the ANP method was chosen to integrate an adapted BSC framework for sustainability-oriented innovation management systems, and to effectively assign importance weights to the KIIs associated with the SIGs, highlighting and quantifying the interdependencies among them.

Based on the results presented in Section 4, one can conclude that the ANP method integrated with the BSC framework could help organisations to handle the effects of the dependencies across the BSC perspectives and over time, as illustrated by the case of the Alpha Company. With a clearer and more systemic understanding of the dependency issue, decision makers can design and implement effective innovation management systems that consider the organisation's vision of business sustainability.

A third conclusion refers to the total alignment of the conceptual model with five guiding principles [34]: (i) multidimensional orientation; (ii) innovation process orientation; (iii) interdependence and feedback loop analyses; (iv) stakeholder goal orientation; (v) ease of use and implementation.

The applicability of the proposed model to an innovative company in the Brazilian electricity sector was demonstrated through an empirical study conducted in 2021, the findings of which are presented and discussed in Section 4.

The flexibility of the conceptual model was confirmed during the empirical study conducted on the Alpha Company as a helpful measurement and evaluation tool that can be adapted to different organisational contexts. Similar to many other empirical studies, it is situationally unique. Nevertheless, the general elements of the conceptual model and methods employed (i.e., the BSC framework combined with the ANP and the hybrid AHP/TOPSIS methods) can be replicated by organisations in other business contexts. Particularly for companies that operate in the Brazilian electricity sector, the model can be used as a benchmarking tool because a core set of key innovation indicators are used as the sectoral SOIC and SOIP indicators and metrics.

Because the study's nature is essentially methodological, we plan to develop a multiple-case study that focuses on organisations from various sectors to demonstrate the proposed BSC framework's applicability and validity in other business contexts. In addition, we intend to use a fuzzy logic approach instead of consensus-building meetings in the second and third phases of the framework during the subsequent study.

Future research could include more in-depth analyses of the SOIC and SOIP indicators and indexes that address the lack of benchmarking models for comparing organisations within the same business context. Assuming that each organisation's sustainability strategy is unique, benchmarking information is helpful for comparing the SOIC and SOIP in a given context. Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) could be used in benchmarking modelling to address this suggestion.

Another suggestion is the use of the 'Decision-Making Trial Evaluation Laboratory' (DEMATEL) combined with the ANP method. The DEMATEL uses the concept of graph theory to build visualized structural approaches based on cause–effect diagrams that show the interdependencies and feedback loops between the factors in complex systems.

Finally, the use of common innovation indicators for the SOIC and SOIP of organisations in the same business context is essential to the acceleration of the transition to the achievement of the SGDs as stated in the UN 2030 Agenda because it could help sustainability-oriented organisations to better define balanced assessment frameworks to

improve the current practices for measuring and evaluating their SOIC and SOIP, allowing them to adjust their strategies to create sustainable value for the new era of business.

Appendix A. Search Histories in Web of Science and Scopus Databases

Table A1. Search strategy for Web of Science database.

Number	Keyword Search	Documents
#1	TS = ("sustainability-oriented innovation" OR "sustainable innovation")	1111
#2	TS = ("innovation management" OR "innovation measurement" OR "innovation indicator*" OR "innovation metric*")	4142
#3	TS = ("R&D management" OR "R&D measurement" OR "R&D indicator*" OR "R&D metric*")	663
#4	TS = ("balanced scorecard" OR BSC)	9004
#5	TS = ("multicriteria decision-making method*" OR "multiple criteria decision-making method*" OR MCDM OR MCDA)	13,086
#6	#2 AND #4	26
#7	#3 AND #4	13
#8	#6 OR #7	36
#9	#8 AND #1	0
#10	#8 AND #5	2
#11	#9 AND #10	0

Note: Search strategy and assessment on 15 November 2022.

Table A2. Search strategy for Scopus database.

Number	Keyword Search	Documents
#1	TITLE-ABS-KEY ("sustainability-oriented innovation" OR "sustainable innovation")	1761
#2	TITLE-ABS-KEY ("innovation management" OR "innovation measurement" OR "innovation indicator*" OR "innovation metric*")	6235
#3	TITLE-ABS-KEY ("R&D management" OR "R&D measurement" OR "R&D indicator*" OR "R&D metric*")	1074
#4	TITLE-ABS-KEY ("balanced scorecard" OR BSC)	11,689
#5	TITLE-ABS-KEY ("multicriteria decision-making method*" OR "multiple criteria decision-making method*" OR MCDM OR MCDA)	16,187
#6	#2 AND #4	25
#7	#3 AND #4	6
#8	#6 OR #7	30
#9	#8 AND #1	0
#10	#8 AND #5	0
#11	#9 AND #10	0

Note: Search strategy and assessment on 15 November 2022.

Appendix B. Innovation Capacity and Performance Measurement Models Based on BSC Framework

Table A3. Summary of conceptual and empirical studies on innovation capacity and performance measurement based on BSC framework.

Authors [Ref.]	Focus	Objective	Methodology
Kerssens-van Drongelen and Cook [21]	R&D outcome and process	To assess the impact of the R&D performance measurement in relation to the overall business performance within the context of global performance evaluation and the theory of independence.	• Scorecard approach; • Research in secondary sources; • Survey research; • Interviews.
Godener and Soderquist [22]		To demonstrate the main areas of use and impact of the results of measuring the R&D performance and new product development.	• Scorecard approach; • Research in secondary sources; • Interviews.
Bremser and Barsky [23]		To propose a system for measuring the R&D performance, integrating the Stage-Gate approach to R&D management with a balanced scorecard.	• Integrating scorecard and Stage-Gate approaches.
Ojanen and Vuola [24]		To propose a new practical tool to visualise and categorise the dimensional aspects in the analysis of the R&D performance and selection of indicators and metrics for R&D management.	• Scorecard approach; • Qualitative content analysis.
Chiesa et al. [25]		To propose a system for measuring the performance of R&D units, according to the scorecard approach and based on a literature review and case studies.	• Scorecard approach; • Survey research; • Research in secondary sources.
Lazzarotti et al. [26]		To propose a conceptual model for measuring the performance of R&D activities based on a systemic and balanced structure of the quantitative indicators from five different performance perspectives.	• Scorecard approach; • Literature review; • Case study.
Jyot and Deshmukh [27]		To present a conceptual model for evaluating the performance of R&D organisations from four BSC perspectives: 'Financial', 'Customers', 'Internal Business Processes' and 'Innovation and Learning'.	• Scorecard approach; • Literature review.
Verhaeghe and Kfir [28]	Innovation capacity and performance	To propose an innovation management measurement model based on a scorecard approach and considering ten assessment dimensions.	• Scorecard approach; • Research in secondary sources; • Interviews with R&D managers.
Gama et al. [29]		To propose an innovation scorecard system based on innovation indicators and metrics, combined with the traditional BSC.	• Scorecard approach; • Literature review; • Case study.
Vinkemeier [30]		To combine well-known management instruments (i.e., BSC [16–18] and technology roadmaps to propose an innovation-adapted BSC that can elicit and measure the innovation performance aligned to the relevant information from technology roadmapping.	• Scorecard approach; • Technology roadmapping.
Khomba et al. [31]		To redesign the innovation perspective of the BSC to a better adaptation to African organisations. The authors propose an innovation perspective that consists of four components: (i) Africanisation values; (ii) learning values; (iii) customer values; (iv) innovation values.	• Survey research; • Interviews among 18 large Malawian companies.

Table A3. *Cont.*

Authors [Ref.]	Focus	Objective	Methodology
Wu [32]		To investigate the relationship between the use of the BSC and intellectual capital accumulation in Taiwanese companies.	• Scorecard approach; • Structural equation modelling (SEM).
Mohamed [33]		To determine the relationship between the characteristics of the BSC methodology and innovation measurement, considering diversity in the use of the performance measures, the balanced use of the performance measures and the strategic link between the performance metrics.	• Scorecard approach; • Survey research; • Statistical analysis.
Dewangan and Godse [34]		To propose a set of guiding principles for modelling an innovation performance evaluation system, and to develop the model based on the scorecard approach.	• Scorecard approach; • Literature review; • Case study.
Ivanov and Avasilcăi [35]		To propose an analytical framework created by exploiting the key indicators of the organisation used to measure the performance of the innovation processes.	• Scorecard approach; • Literature review; • Cross-sectional analysis; • Case study.
Zizlavsky [36]		To propose a management control system approach to the assessment of the innovation performance at the corporate level by integrating the input-process–output-outcomes and Stage-Gate model applied to innovation management with the balanced scorecard framework.	• Integration of scorecard, Stage-Gate and input-process–output-outcome approaches; • Literature review and documentary analysis; • Interviews.
Spanò et al. [37]	Innovation capacity and performance	To propose an innovation management measurement model based on the BSC approach to improve the measurement and performance evaluations of biotechnology companies that belong to a knowledge-intensive and R&D network.	• Scorecard approach; • Literature review and documentary analysis; • Interviews.
Zhang [38]		To investigate the connection between using the BSC as a strategic management tool and the innovation performance. The author suggests the mediating effect of firm competencies in linking the use of the BSC and innovation management, as well as its performance consequences.	• Scorecard approach; • Literature review; • Descriptive statistics and univariate analysis; • Multilevel regression; • Two-stage least squares.
Saunila and Ukko [39]		To develop a general procedure to clarify how the different performance aspects are linked to the measurement of the effects of the innovation capabilities of organisations. The measurement framework was developed by examining and matching the existing literature on innovation capability and performance measurements.	• Scorecard approach; • Literature review and documentary analysis.
Hájek et al. [40]		To propose a model for strategic innovation performance measurement, integrating a BSC framework and fuzzy-set qualitative comparative analysis.	• Scorecard approach; • Fuzzy TOPSIS method; • Exploratory factor analysis.
Hájek et al. [41]		Continuing the research in [40], the authors developed a model for strategic innovation performance measurement, integrating a BSC framework and fuzzy-set qualitative comparative analysis.	• Scorecard approach; • Fuzzy TOPSIS method; • Exploratory factor analysis.
Dudic et al. [42]		To propose a model for assessing the innovative activities of small- and medium-sized firms in the Republic of Slovakia and Republic of Serbia. To investigate the model's applicability in 223 SMEs in these countries.	• Scorecard approach; • Survey research with a multisection questionnaire (data gathering); • Confirmatory factor analysis; • Structural equation modelling.

Appendix C. Innovation Indicators Associated with Adapted BSC Framework

Table A4. Innovation indicators associated with adapted BSC framework.

SIG11: Innovation-Based Economic Sustainability		
KII	**Innovation Indicator**	**Sources [Ref.]**
I111	Number of commercialized patents and products	[14,15,27,37,49]
I112	ROI of realized patents and products	[15,37]
I113	Royalties of commercialized patents and products per year	[15,37]
I114	Net cash generated by commercialized patents and products per year	[15,26,37]
I115	Budget spent on research, development and innovation (RD&I)	[15,26,27,49]
I116	Share of RD&I budget from total company budget	[15,26,27,49]
SIG12: Innovation-Based Environmental Sustainability		
KII	**Innovation Indicator**	**Sources [Ref.]**
I121	Number of projects with environmental relevance to organisation's region per year	[37]
I122	Number of innovative solutions for circular economy per year	[37]
I123	Improvement rate in use of alternative energy/material due to ecoinnovations	[37]
I124	Number of innovative solutions to mitigate environmental risk per year	[15,37]
I125	Reduction rate of adverse event impact due to ecoinnovations	[37]
SIG13: Innovation-Based Social Sustainability		
KII	**Innovation Indicator**	**Sources [Ref.]**
I131	Number of key external stakeholders integrated into R&D projects to improve sustainability concerns in value chains per year	[15,37]
I132	Number of innovations with social impacts per year	[14,37,49]
I133	Involvement of local SMEs in innovations with impacts on supply chain	[37]
I134	Improvement in occupational rate of organisation's region	[37]
I135	Innovative startup birth rate	[37]
I136	Number of knowledge transfer sessions (KTSs)	[37]
I137	Number of employees dedicated to external relationships in RD&I projects	[14,15,26,49]
I138	Number of local alliances dedicated to RD&I projects	[13,14,26,49]
SIG 21: Higher Competitiveness and New Markets Due to Innovation		
KII	**Innovation Indicator**	**Sources [Ref.]**
I211	Number of new or significantly improved products (goods or services) introduced into market per year	[14,49]
I212	Number of innovative businesses/new venture startups	[15]
I213	Number of firms adopting commercialized patents and products	[37]
I214	Market share of firms adopting commercialized patents and products	[37]
I215	Number of innovative businesses/new venture startups	[15]
I216	New product introduction into market versus competition	[15]
I217	Annual spending for market investigations aimed at generating technological innovation	[26,49]
SIG 31: Innovation Management System Improvement		
KII	**Innovation Indicator**	**Sources [Ref.]**
I311	Number of projects that developed new models, methods and/or standards to improve RD&I practices	[14,15,37,49]

Table A4. *Cont.*

	SIG11: Innovation-Based Economic Sustainability	
I312	Number of new business models or frameworks developed and implemented through collaborative projects	[37]
I313	Percentage of RD&I projects abandoned after a certain degree of completion	[14,15,26,49]
I314	Percentage of successful RD&I projects aligned to innovation strategy toward sustainability	[14,15,26,49]
I315	Time dedicated to analysis of reasons for failure of previous projects	[26]
I316	Percentage of RD&I activities formally documented	[26]
I317	Percentage of RD&I projects respecting established deadlines	[15,26]
	SIG 41: Human and Structural Capital Enhancement	
KII	**Innovation Indicator**	**Sources [Ref.]**
I411	Number of joint training programs for researchers and employees	[37]
I412	Improvement in employee and researcher satisfaction	[37]
I413	Number of meetings among partners	[37]
I414	Number of publications in scientific journals or conferences per year	[15,26,27,37]
I415	Number of new intangibles per year (patents, licenses, copyrights, etc.) per year	[15,26,27,37]
I416	Number of information systems implemented for sharing RD&I data	[37,49]
I417	Number of employees devoted to RD&I activities/total of employees per year	[14,15,26,49]
I418	Percentage of time spent by managers on RD&I activities compared with other business tasks	[15]
	SIG 42: Relational Capital Enhancement	
KII	**Innovation Indicator**	**Sources [Ref.]**
I421	Social engagement in organisation's region	[37]
I422	Number of new cocreated skills and knowledge through RD&I cooperation per year	[37]
I423	Use of internal and external knowledge and information sources	[14,15,26,49]
I424	Transfer rate of new knowledge and technology into product development (goods or services)	[26,27,49]
I425	Number of newly created innovative opportunities with customers, suppliers or partners	[15]
I426	Number of ideas generated with customers, suppliers or partners	[15]
I427	Number of projects funded by external organisations per year	[15,26,27]

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