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Integrating the United Nations sustainable development goals into organizational strategy: A sustainability balanced scorecard approach using ANP and TOPSIS

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ABSTRACT

Challenges related to sustainable development require companies to align their strategies to meet stakeholder interests systematically. The United Nations Sustainable Development Goals (SDGs) are guiding objectives for sustainable development on an international level up to 2030. This article links the goals of the SDGs to a recognized strategic management tool: the sustainability balanced scorecard (SBSC). So far, few approaches exist in this field. Consequently, this article presents a framework for developing and applying an SBSC that takes an integrative view of the SDGs. For this purpose, the analytic network process (ANP) and the technique for order preference by similarity to an ideal solution are applied (TOPSIS). The article concludes that the solution approach presented has considerable potential to support organizations in systematically integrating the SDGs into their strategy. Also, this article proposes interesting future research directions.

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1. Introduction

Sustainable development seeks to meet the needs of current generations while ensuring that future generations can also meet their needs. This mission embodies the central core principles of intergenerational and intragenerational equity [1]. The United Nations Sustainable Development Goals (SDGs) announcement is a milestone in the cross-national alignment of economic, environmental, and social development ambitions [2]. The United Nations General Assembly views these three dimensions as an integrated, inseparable, and balanced set [3]. In this agreement, the member states agree at the political level to realize 17 SDGs and 169 associated targets by 2030 [2–4]. A group of experts from the United Nations Statistical Commission (UNSC) is responsible for developing the globally relevant indicators. The development of the reference framework started with a baseline of 300 indicators under consideration, which the UNSC reduced through a consultative process [5]. This process has resulted in currently 231 unique indicators, some of which can be used for different objectives and are being further developed at national and regional levels by the member states [6]. The United Nations General Assembly agreed on these indicators in a resolution [7]. Companies play a vital role in fulfilling politically driven goals [8]. Issues of corporate strategy, performance measurement, and corporate reporting receive great attention in this regard [2]. Corporate strategy, and systematic management approaches, e.g., the Balanced Scorecard (BSC), performance measurement, and corporate governance contribute to an integrative consideration of the SDGs and ensure value creation from a long-term perspective [9]. Companies must pay particular attention to the interdependencies between the individual SDGs and their respective influences on the overall goal achievement [2]. These highlighted subjects provide promising research opportunities. The BSC emerged in the 1990s when researchers questioned traditional financial performance measures. The four-perspective BSC aims to consider short- and long-range goals, reflect financial and non-financial measures, integrate lagging and leading indicators, and provide insights into internal and external performance perspectives [10]. The BSC aims not to view the company exclusively from a retrospective perspective but to prepare the company strategically for future challenges and derive appropriate measures to create future-oriented value and generate long-term competitive advantages [10].

The BSC suits the corporate management of sustainable development as it provides the capability to consider the sustainability dimensions interactively. Also, the approach assists companies in improving their performance within these sustainability dimensions. Another advantage of the BSC is that companies can consider non-financial factors. Integrating sustainability dimensions into traditional economic management is helpful in avoiding environmental and social satellite systems in management. This article deals with the Sustainability Balanced Scorecard (SBSC) as an extended BSC form to create future-oriented values and generate competitive advantages concerning the SDGs [11].

Few approaches exist that link the SDGs with an SBSC. One approach is the combined model of integrated social accounting and the SDGs, with the model having four perspectives inspired by BSC [12]. These perspectives address the SDGs. Mook first officially refers to this model as a BSC in a subsequent article [13]. Using existing

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frameworks for reporting and applying creativity techniques may assist in identifying relevant indicators [13]. Pereira Ribeiro et al. analyze the BSC for sustainable food production by combining the tool with the Water, Energy, Food-Nexus approach [14]. Accordingly, the four traditional perspectives of the BSC are modified and combined with the SDGs and Brazilian public policies [14].

Another approach combines corporate social responsibility, the SDGs, and the BSC to support companies' strategic, sustainability-focused alignment and value creation [15].

People find themselves making complex and challenging decisions [16,17]. This article is about deciding how a BSC should be designed and evaluating alternative courses of action. In recent decades, decision-making has become increasingly important in research [16,17]. Decision aiding assists individuals in making decisions within a process by suggesting behavioral recommendations for specific problems [18].

Multicriteria approaches systematize the relevant and suitable factors for decision-making, capture the interdependencies between these factors, and allow for detailed consideration, e.g., in the form of weightings, aspiration levels, and differentiated assessments [18]. The existence of vagueness and uncertainty in real decision-making situations, as well as the influence of organizational, pedagogical, and cultural factors on the decision-making process, limit objectivity in decision-making [18]. A systematic approach to decision-making can reduce complexity by modularizing decision problems and formalizing decision processes, thus contributing to better outcomes [19].

This article presents a detailed procedure for integrating the SDGs into the SBSC. Therefore, a process-oriented model is defined to link the SDGs with the SBSC. This process uses decision-making methods to develop an organization-specific Sustainable Development Goals Sustainability Balanced Scorecard (SDGSBSC). This goal leads to the following research questions:

- How is a process designed to integrate the SDGs into the SBSC for developing an SDGSBSC?
- Which decision-making methods support the process of developing an SDGSBSC?

The remaining sections of this article are structured as follows. Section 2 outlines the theoretical foundations for developing the solution. In section 3, the process development, a fictional illustrative example, and the discussion of the results follow. Section 4 includes implications. Also, this section recommends future research directions. Section 5 concludes this article.

2. Theoretical foundations

This section covers the underlying theoretical foundations. It introduces sustainability, subsequently the SBSC, and relevant MCDM techniques.

2.1. Sustainability

Sustainable development on a macro level is a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1]. Critical voices note that operationalizing and implementing this definition is challenging and question how to assess decisions using this definition in corporate contexts [20].

Dyllick and Hockerts apply the definition to the corporate level and postulate [21]. That corporate sustainability is responsible for "meeting the needs of a firm's direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities, etc.), without compromising its ability to meet the needs of future stakeholders" [21].

One approach to operationalization is to consider the triple bottom line (TBL) with its economic, environmental, and social dimensions [22]. An integrative view of the three TBL dimensions becomes necessary [22]. Other authors follow this operationalization approach [2,3,21,23]. It is feasible to add other dimensions, such as the cultural, institutional, or technical dimensions [24,25]. Authors of this article acknowledge the influence of the previously mentioned cultural, institutional, and technical aspects on sustainability. However, this article follows the reasoning of Dalal-Clayton and Bass as well as Lozano, which states that politics, peace and security aspects, cultural values, technical factors, and institutional and administrative settings have an impact on the three sustainability dimensions but are not individual dimensions of their own [26,27].

Dyllick and Hockerts propose a model that allows an integrative consideration of the TBL dimensions by constructing a triangle of economic, environmental, and social effectiveness and linking these ends with eco-efficiency, socio-efficiency, sufficiency, and ecological equity [21]. Figure 1 illustrates the interrelationships of the triangular elements before this article outlines associated challenges.

The following describes the inherent challenges associated with these elements [28]:

- Environmental challenge: Due to the limited viability of ecosystems, companies need to take measures that have an effective impact on ecosystems (environmental effectiveness). Moreover, companies must demonstrate ecologically fair behavior (ecological equity) towards their stakeholders.
- Social challenge: Corporate activities must contribute effectively to society (social effectiveness). This means reducing impact factors that negatively affect the social system and strengthening impact factors that positively affect the social system. Also, companies have to recognize consumption as an essential factor. If the eco-efficiency of products increases but the consumption level simultaneously rises, this rise can nullify an efficiency improvement.

- Economic challenge: To remain competitive, companies need to consider their activities in terms of the interplay between economic performance and the impact on the environment (eco-efficiency) and society (socio-efficiency). The purpose is to enhance value creation and mitigate the negative environmental and social impact.
- Integration challenge: This challenge is twofold. First, the TBL dimensions and the challenges mentioned above must be dealt with jointly. Second, companies must integrate environmental and social management into classical economic-oriented management.

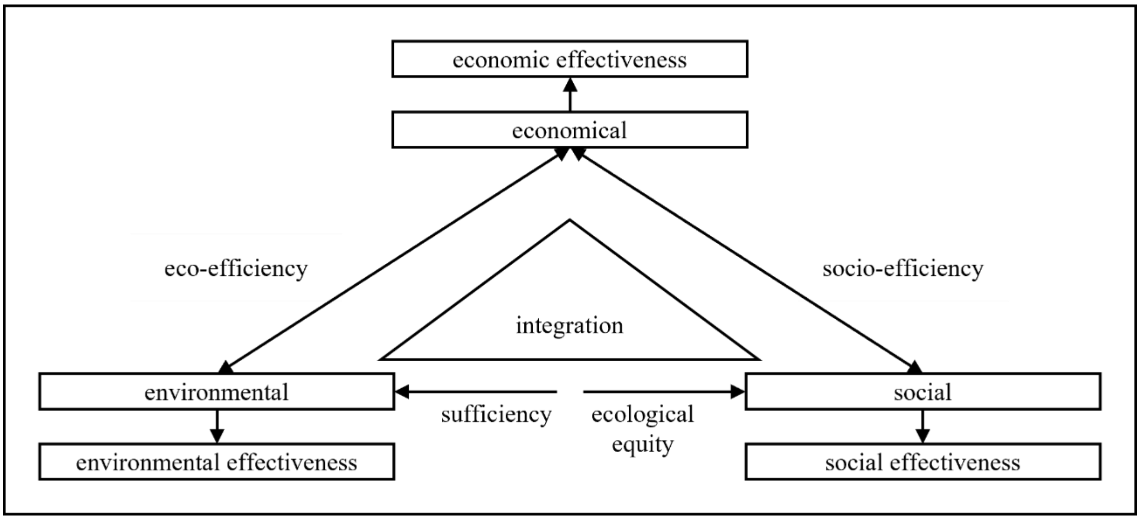

Figure 1. Challenges of corporate sustainability management adapted from [11,21].

2.2. Sustainability balanced scorecard

The BSC aids business units in creating value for customers from a strategic perspective, improving business processes, building essential capabilities, and enhancing companies' economic effectiveness and competitiveness [10]. The four perspectives of the traditional BSC can be delineated as follows [10]:

- The financial perspective addresses performance measures to assess activities from an economic perspective. These measures reflect whether the corporate strategy, its deduction in objectives, and measures contribute to improving companies' economic success.
- The customer perspective focuses on business units' relevant customer and market segments. Measures capture the objectives and assess the performance within the target segments.
- The internal-business-process perspective sheds light on critical internal business processes. Business processes are the foundations for providing tailored value propositions to target segments and meeting shareholder expectations.
- The learning and growth perspective highlights the required infrastructure for long-term growth and continuous improvement as capabilities and technologies to achieve goals in the customer and internal-business-process perspective.

Business units must first determine their vision and transfer it into strategies to build the BSC. Then, they communicate their strategic objectives and operationalize the measures. Finally, the participants reflect on the activities and derive their learnings [10]. Although there is no rule prescribing several measures, too many measures may compromise the focused strategy definition [29].

There are specific prescriptions to link the strategy with the BSC perspectives [10]:

- Cause-and-effect relationships: Each measure should be part of cause-and-effect relationships.
- Performance drivers: Each BSC contains adequate lagging indicators and leading indicators.
- Linkage to financials: The cause-effect relationships link all measures to the financial perspective.

The traditional BSC perspectives provide guidance and are not unchangeably predefined; thus, the perspectives are adaptable depending on the specific business unit's requirements [10]. One possibility is to broaden the customer perspective to include stakeholders. Following Freeman and Reed, including a broader range of stakeholders means considering "any identifiable group or individual who can affect the achievement of an organization's objectives or who is affected by the achievement of an organization's objectives" [30]. The benefit of incorporating a broad stakeholder spectrum is that business units consider friendly and antagonistic positions in their strategy design to generate competitive advantages [30]. Norton and Kaplan advocate including stakeholders in the BSC if they influence the results of business units [10].

Many environmental and social challenges have a non-financial character, so the BSC may support business units in connecting long-term, non-financial challenges with short-term financial results [31]. The selection and prioritization of environmental and social measures are context-specific and depend on business units' mission, cultural characteristics, and objectives [29]. A broad spectrum of research settings exists for SBSC, which has increasingly expanded in recent years [31].

Integrating sustainability into the BSC creates an SBSC. Three pathways to integration exist: (1) the four traditional BSC perspectives incorporate environmental and social aspects, (2) another perspective is added to the traditional BSC that includes environmental and social aspects, and (3) a specific scorecard containing environmental and/or social aspects is created [11]. The first variant ensures that the environmental and social aspects are directly considered in the cause-effect relationships of the traditional BSC within a market perspective context. This approach faces challenges when aspects are not aligned with market mechanisms [11]. The second variant overcomes this challenge of the first variant by introducing a non-market perspective. This additional perspective integrates strategically relevant environmental and social factors that are outside market mechanisms [11]. The third variant builds as a second step on one of the two previous alternatives. It derives an independent environmental and/or social scorecard from enabling a more detailed differentiation of the challenges. The other two variants with the traditional BSC perspectives embed these scorecards [11]. Since this article creates a framework for integrating a first SDGSBSC, the remainder does not address this third variant. The first two variants are not mutually exclusive, so companies should not decide in favor of one variant in advance but during the SBSC development. The addition of a non-market perspective is permitted with two conditions being fulfilled: (1) the aspects in question are environmental or social aspects with strategic relevance, and (2) it is impossible to integrate these aspects into the traditional BSC perspectives. The procedure of an SBSC development relies on the original BSC development process adding environmental and social aspects. The process includes the following development steps: (1) choose a strategic business unit, (2) identify environmental and social exposure, (3) determine strategic relevance of environmental and social aspects, and (4) specify each perspective [11].

2.3. Multiple Criteria Decision-Making (MCDM)

Multiple criteria decision-making (MCDM) comprises formal approaches that support individuals or collectives in deciding on alternatives under consideration of more than one criterion [32,33]. Individuals or collectives that make the decision form the decision-making unit (DM). Authors in the literature distinguish MCDM methods mainly into multi-attribute decision making (MADM) methods and multi-objective decision making (MODM) methods [17,34,35]. MADM methods aim at selecting a suitable alternative from a specified list of discrete alternatives [34,36]. In contrast, MODM methods are suitable for an infinite number of continuous alternatives determined implicitly by constraints on decision variables [34,36,37]. Many MCDM methods are similar in some aspects they share [32,33,35]:

- Alternatives: They define the choices of action available a DM has to prioritize.
- Multiple criteria: They provide the set of dimensions by which the alternatives may be assessed. Criteria can be represented without a hierarchy, within a hierarchy, or network. If the criteria values are known and certain, the MCDM problems are deterministic. Else they are nondeterministic.
- Conflicting criteria: As different criteria reflect various dimensions of given alternatives; these criteria can conflict.
- Conflicting DM: Views within the DM may vary, leading to conflicts in decision-making.
- Weighting: Different criteria may be weighted differently to reflect their relative importance.
- Incomparable units: Considering multiple measurement units of different criteria increases the difficulty in solving MCDM problems.

MCDM problems often do not have an optimal solution because conflicting criteria and objectives mean a DM cannot simultaneously obtain an optimal solution for each objective function [34]. Consequently, an optimal solution can often only be approximated [18].

Figure 2 depicts the main steps of the MCDM process. The phases address problem identification and structuring, model building and deployment, and action plan development [32].

Formalized models help DM develop a shared understanding of a specific problem under discussion. This includes representing, structuring, and synthesizing values and information to evaluate action choices. The MCDM process leads to better reasoned, defensible and explainable decisions that can be transparently monitored through the process [32]. This article draws on the analytic network process (ANP) and the technique for order preference by similarity to ideal solution (TOPSIS).

2.4. Analytic Network Process (ANP)

The analytic hierarchy process (AHP) or the ANP, a generalization of the AHP for feedback networks, is a method for representing and modeling problems with hierarchical or networked structures. The methods support pairwise comparisons and illustrate relationships within these structures [38]. The ANP extends the AHP's scope of action by including the interactions and dependency of higher-level elements on lower-level elements.

In contrast to a hierarchical top-down structure of the AHP, the ANP links the existing clusters with cycles and loops within the clusters. Decision problems, including feedback loops, frequently appear in real-world situations. Here the challenge is prioritizing the network's elements and the decision alternatives. The ANP reflects the given complexity of a real-world problem better than the AHP. The AHP simplifies a problem artificially due to its hierarchical structure, so the results and the resulting decisions do not fully reflect the real problem [38].

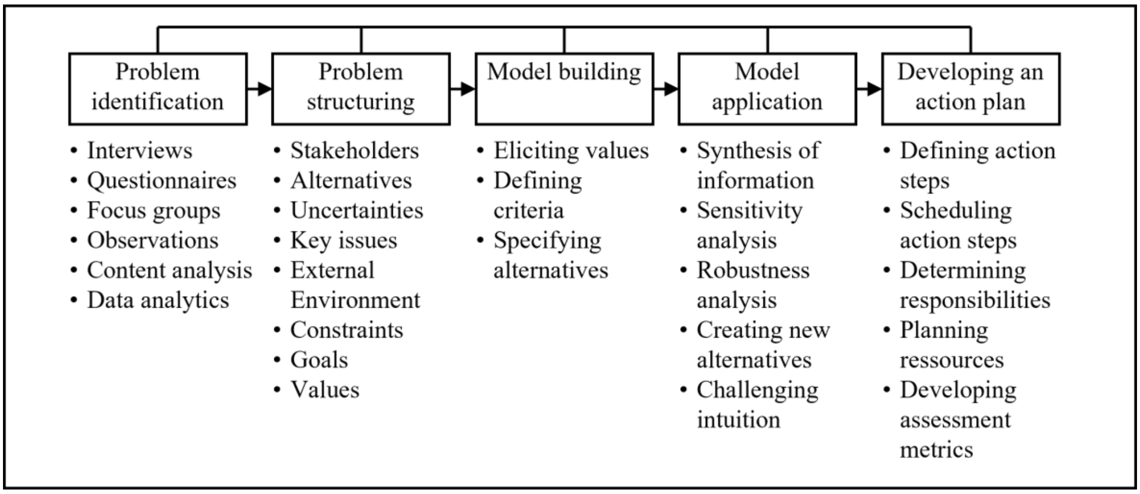

Figure 2. Figure 2: MCDM process adapted from [32].

ANP addresses network components' structural dependence in several relative comparisons [39]. There are outer dependencies between different components and inner dependencies between elements within a component [38].

The ANP steps are as follows: (1) describing the decision problem, (2) determining the control criteria and sub-criteria, (3) specifying the most general network, (4) identifying inner and outer dependencies, (5) selecting an analysis approach, (6) constructing the super matrices, (7) performing pairwise comparisons with elements, (8) performing pairwise comparisons with clusters, (9) computing the limit matrix and synthesizing results, (10) conducting a sensitivity analysis [40]. This article follows Saaty's approach and uses the recommended 9-point scale to prioritize within the pairwise comparisons [38]. The Super Decisions software has integrated ANP as functionality and has been used in various problems [41]. Therefore, it supports the computational work to solve the problem in the context of this article. At this point, this article recommends Blockus for a detailed discussion of methodological principles and the mathematical background of the ANP [42].

2.5. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS is an MCDM method introduced by Hwang and Yoon in 1981. The aim of solving an MCDM problem is to select the alternative with the shortest distance to the ideal solution and the largest distance to the negative-ideal solution. The method assumes a monotonic increase or decrease of a criterion's utility. The (weighted) minimum Euclidean distance represents a suitable distance measure [34].

The TOPSIS algorithm is divided into the following six steps: (1) constructing the normalized decision matrix, (2) constructing the weighted normalized decision matrix, (3) calculating the ideal and negative-ideal solutions, (4) calculating the separation measure, (5) calculating the relative closeness to the ideal solution, and (6) ranking the preference order [34,43]. This article follows this original approach in most respects. Although, the article carries out an extension to determine the collective decision-making group separation measures. This step follows the calculation of the individual separation measures by using the geometric mean to synthesize these measures [44].

3. Findings and discussion

This section first describes the general procedure for integrating the SGDs into the SBSC to create an SDGSBSC. In a second step, the section illustrates the procedure before concluding with a discussion of the results.

3.1. Model development

As described in section 2.3, ANP and TOPSIS are employed in this article to integrate the SDGs into the SBSC and develop an SDGSBSC. Therefore, the following sections describe the general process model. The model consists of three overarching steps: (1) problem identification and problem structuring, (2) model building, (3) model application, and (4) developing an action plan. Figure 3 shows the steps involved in creating and using the SDGSBSC.

First, the organization defines the problem and analyzes it. Therefore, the organization nominates an expert group to deal with the development and evaluation process of the SDGSBSC. They form the DM. The organization develops a vision, derives strategies based on it, and integrates relevant stakeholders into its analysis. This article's stakeholder perspective substitutes the traditional BSC's customer perspective. The business unit then addresses goal setting. Since this article develops an SDGSBSC, selecting suitable SDGs follows based on the strategy.

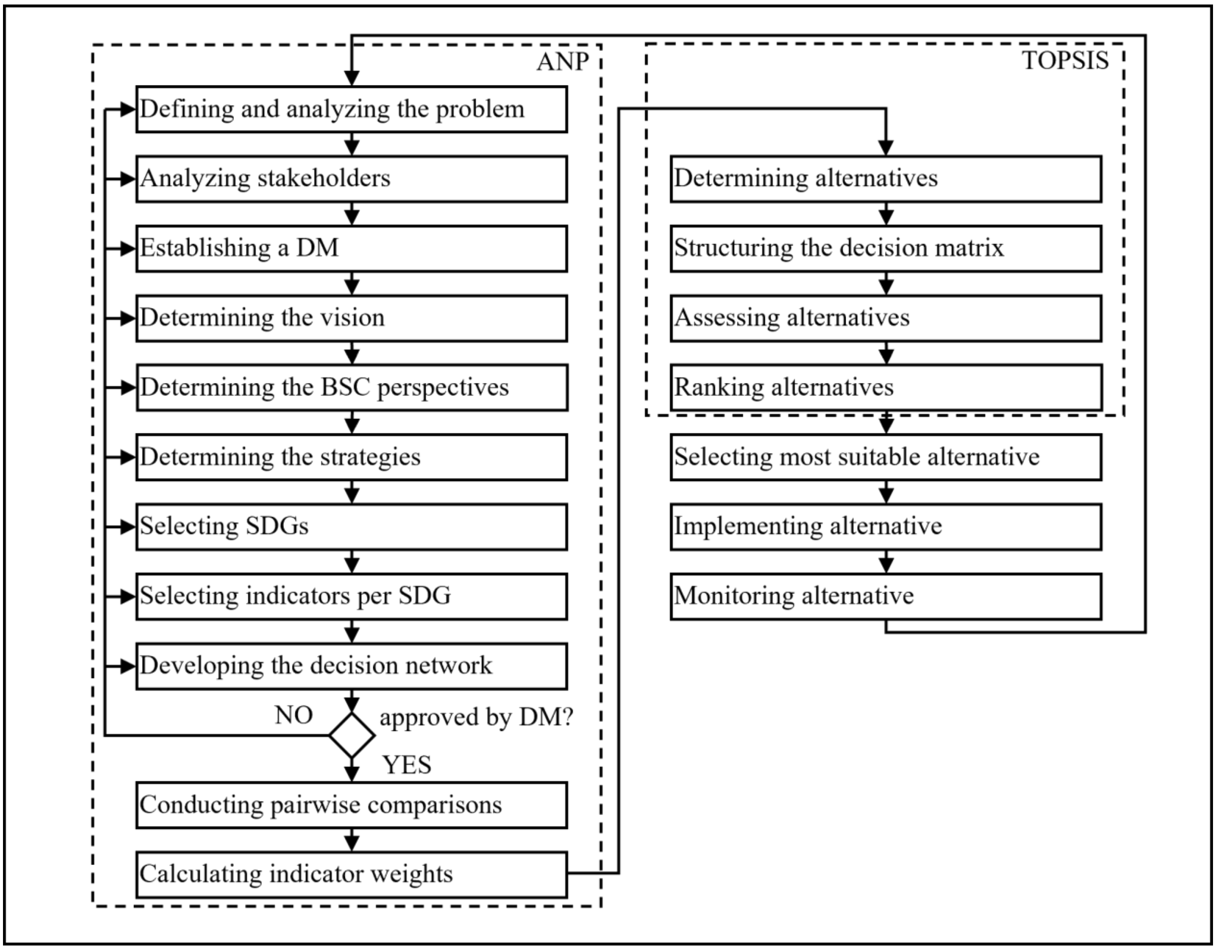

Figure 3. Process for developing the SDGSBSC.

In many cases, the officially proposed SDG indicators appear less suitable for application in a business context. Consequently, they are not ideal as BSC indicators in a business context. A selection of indicators appropriate for business is necessary. Therefore, this approach involves various reporting frameworks, e.g., the Global Reporting Initiative (GRI) standards. Corporate sustainability reports often use these frameworks. They include a range of possible indicators for sustainability assessment, which is why they guide BSC indicator selection. Due to their frequent use, practitioner accepts these frameworks widely.

Nevertheless, it would also be possible to define company-specific indicator frameworks. For example, companies can conduct this creation process in workshops. To the extent that various BSC indicators exist for an SDG, the decision-makers must prefer one BSC indicator for each SDG. This agreement simplifies the BSC evaluation process since the DM needs to evaluate fewer indicators. This results in a collection of fewer data as part of an assessment. Then, the SDGs are assigned to the traditional BSC perspectives if this is feasible. Otherwise, the DM adds a non-market perspective (see section 2.2). Once set, cause-and-effect relationships connect the selected SGDs. The interconnection emphasizes that the indicators are not mutually exclusive but impact each other and affect the objective achievement. At this point, the SDGSBSC is ready for use. The SDGSBSC incorporates both the TBL dimensions and the SDGs and supports addressing the environmental, social, economic, and integration challenges (see section 2.1). ANP develops the SDGSBSC network (see section 2.3.1). Since many stakeholders are involved in the decision-making process, the final weights of the individual SDGSBSC components in this article are determined by the geometric mean to proceed with uniform weights.

Once the DM has determined the weightings of the individual SDGs concerning the corporate vision, the evaluation of alternative courses of action follows. Therefore, the DM chooses a corresponding indicator from the reporting frameworks and links it to each SDG. Subsequently, TOPSIS is employed to determine the ranking of the alternatives (see section 2.3.2). The ranking forms the basis for the subsequent decision in the narrower sense. This article does not consider this decision step in more detail in the narrower sense. Once the organization has selected an alternative, the organization implements it. Therefore, suitable monitoring must occur in parallel to react quickly to changing conditions and generate a more extensive information base for future decisions. This step is not the subject of a more in-depth examination in this article.

3.2. An illustrative example of model application

A fictional organization performs the process of creating the SDGSBSC using ANP and evaluating alternative courses of action using TOPSIS. The organization establishes an expert group of two managers from different business units to form the DM. The decision making process follows the steps outlined previously.

The DMs specify that stakeholders should perceive the organization as a good brand that contributes to safeguarding intra- and intergenerational equity in the future. Consequently, the DMs want to comprehensively integrate sustainability into the organizational vision (OV). They see this as an opportunity to generate a competitive advantage, as relevant stakeholders demand this from the media, political institutions, and customers. This competitive advantage should also deliver added value to shareholders in financial terms.

The DMs decide to modify the four traditional perspectives of the BSC. The financial perspective (P1), internal business process perspective (P2), and learning and growth perspective (P3) remain as in the traditional scorecard. First, they replace the customer perspective with the stakeholder perspective (P4). Moreover, the DMs keep open the question of whether the expert group should integrate a fifth non-market perspective (P5) into the BSC. However, the DMs agree to use the non-market perspective only if it is impossible to assign strategically relevant objectives to any other views. Otherwise, the perspective is obsolete.

The DMs define three strategies to achieve the vision. The DMs choose the following strategies:

- Consideration of economic consequences (S1) for alternative actions.
- Consideration of ecological consequences (S2) for alternative actions.
- Consideration of social consequences (S3) of alternative actions.

A special concern of the DM is to consider the three perspectives integrated. The DM chooses to comprehensively consider the SDGs proposed by the United Nations to achieve the organization's vision. The SDGs are as follows [3]: (G1) No poverty, (G2) Zero hunger, (G3) Good health and wellbeing, (G4) Quality education, (G5) Gender equality, (G6) Clean water and sanitation, (G7) Affordable and clean energy, (G8) Decent work and economic growth, (G9) Industry, innovation and infrastructure, (G10) Reduced inequalities, (G11) Sustainable cities and communities, (G12) Responsible consumption and production, (G13) Climate action, (G14) Life below water, (G15) Life on land, (G16) Peace, justice and strong institutions, (G17) Partnership for the goals.

The DMs select one suitable BSC indicator per SDG using the SDG Compass database. It draws on existing indicators from the business context and compares them with SDGs. For example, the tool refers to the GRI standards [45]. These indicators are not the only way to operationalize SDGs. Companies can use these existing indicators as an inspiring source and develop them further or create their own indicators. The indicator nomenclature $Ix.y$ describes the y^{th} indicator I by SDG x. The following exemplary indicators from the SDG Compass database represent the SDGs:

- I1.1: local minimum wage payment
- I2.1: infrastructure investments supported
- I3.1: days lost and absences due to occupational diseases
- I4.1: average hours of training per year per person
- I5.1: gender pay gap by employee category
- I6.1: compliance with relevant water quality standards
- I7.1: GHG emissions
- I8.1: profit margin
- I9.1: investments in research and development projects
- I10.1: equal distribution of new hires concerning diversity guidelines
- I11.1: negative ecological impacts of the alternative on the city and community
- I12.1: reductions in energy requirements of products and services
- I13.1: investment in climate protection projects
- I14.1: the extent of water bodies and associated habitats impacted by the organization's water supply and wastewater disposal
- I15.1: number of operating sites in protected areas or neighboring protected areas
- I16.1: confirmed incidents of violation against compliance guidelines
- I17.1: stakeholder orientation

As already stated, the SDG Compass database provides above mentioned illustrative indicators. If there are several potential indicators for an SDG, a more detailed description of the selection process from the database would be necessary to prioritize an indicator. Similarly, a method for developing company-specific BSC indicators is not part of this article. The following step presents a weighting between selected indicators.

The next step is to visualize the decision network. It consists of the organizational vision (OV) as the overarching goal. Below this, the mandatory BSC perspectives (P1-P4) and the optional BSC perspective (P5) follow. The decision network considers the three strategic directions (S1-S3) subsequently. The SDGs (G1-G17) connect to them. An indicator (I1.1-I17.1) represents each SDG. Figure 4 depicts the exemplary SDGSBSC network.

The BSC perspectives (P1-P4) derive from the vision (OV). The BSC perspectives (P1-P4) are linked to the respective strategies (S1-S3) so that sustainability is viewed interactively in organizational management. Because the perspectives influence each other reciprocally, they are also interconnected.

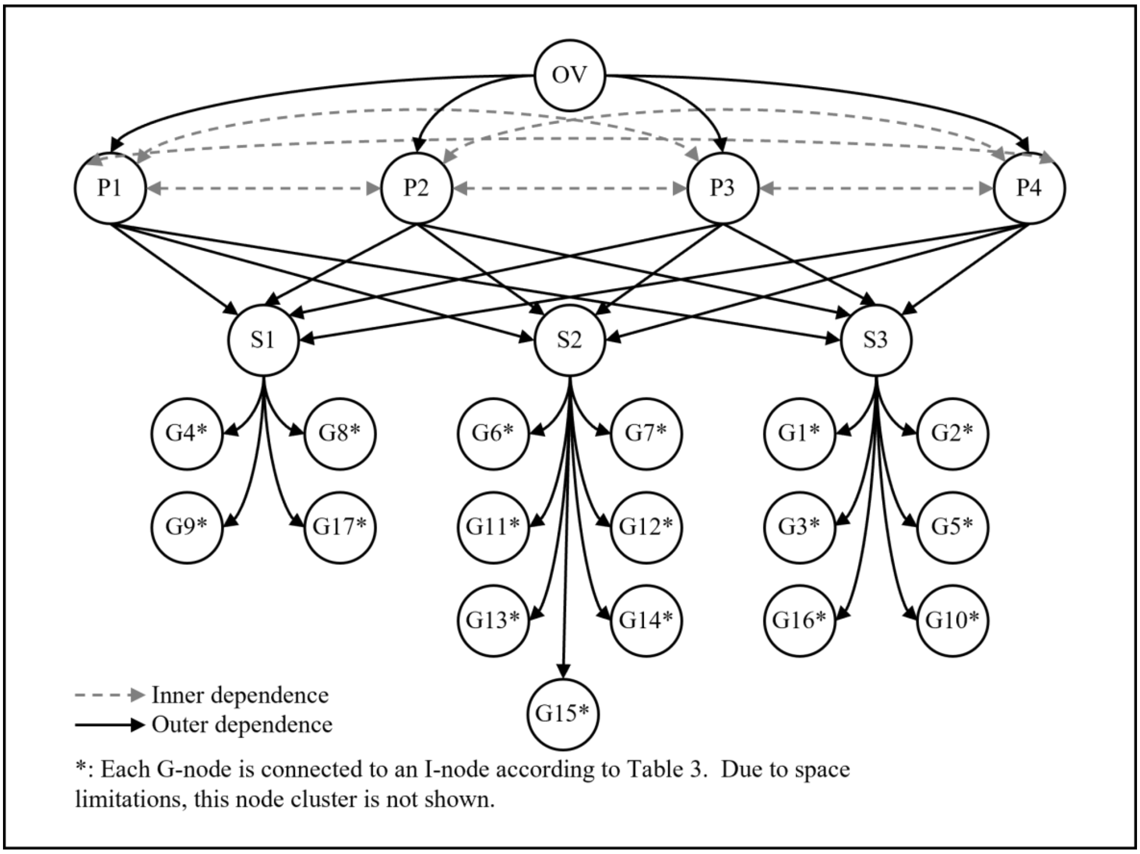

Figure 4. Exemplary SDGSBSC network.

Next, the organization performs pairwise comparisons. This execution takes place at each level to obtain local priorities and corresponding weights. Each DM expert compares two elements concerning a higher-level criterion in the control hierarchy using the scale presented earlier (see section 2.3.1). Accordingly, DMs create a comparison matrix for each higher-level criterion of the control hierarchy. For each comparison matrix, the DMs determine the eigenvector. The eigenvector w provides the local priorities or weights of the elements. Another requirement for pairwise comparisons is consistency. Niemira and Saaty recommend that the practical level of inconsistency should be less than 10%; otherwise, an assessment should be repeated [46]. Details of all pairwise comparisons are available in Appendix A. After performing the pairwise comparisons, the local and global weightings become apparent in the Super Decisions software. The software performs the computational steps. There is no distinction between the experts regarding their importance in this example. Consequently, the process includes weightings from the Super Decisions software in the aggregated weightings in equal proportions. The geometric mean is first calculated to obtain the common weight per indicator. Then normalization of the computed values follows. Since DMs only selected one indicator for each SDG, the weights of the SDG cluster and indicator clusters' weights are equal. TOPSIS applies weights shown in Table 1. More details are given in Appendix B.

Table 1: Weights per indicator.

indicator	I1.1	I2.1	I3.1	I4.1	I5.1	I6.1	I7.1	I8.1	I9.1
weights	0.0700	0.0865	0.0641	0.0529	0.0305	0.0292	0.0331	0.0902	0.1909
indicator	I10.1	I11.1	I12.1	I13.1	I14.1	I15.1	I16.1	I17.1	∑
weights	0.0296	0.0200	0.0566	0.0697	0.0318	0.0290	0.0340	0.0818	1.0000

In this example, the experts decide whether to integrate company 1 or company 2 into the organization. Integrating one of the companies is necessary to expand the organization's scope of action. The experts define I1.1, I2.1, I4.1, I6.1, I8.1, I9.1 - I13.1, and I17.1 as benefit criteria (B). The indicators I3.1, I5.1, I7.1, I11.1, I14.1 - I16.1 form the group of cost criteria (C). Table 2 presents the evaluation scheme.

Table 2: Evaluation scheme for TOPSIS.

Indicators	Degrees (values)
I1.1, I6.1	yes (2), no (1)
I2.1 - I5.1, I7.1 - I9.1, I11.1 - I17.1	high (3), medium (2), low (1)
I10.1	balanced (4), rather balanced (3), rather unbalanced (2), unbalanced (1)

Subsequently, the experts evaluate both companies against the criteria using the evaluation scheme (see Table 2). The initial matrices are first normalized and then weighted with the weights presented in Table 1. Then the ideal and negative-ideal solutions are determined from the point of view of the respective expert $e = 1, \ldots, E$. This is followed by the calculation of the Euclidean distances per expert and alternative as separation measures to the ideal solution S_i^{e*} and the negative-ideal solution S_i^{e-}. The TOPSIS approach yields the following separation measures for the first expert: $S_{company\ 1}^{1*} = 0.0619$, $S_{company\ 2}^{1*} = 0.0747$, $S_{company\ 1}^{1-} = 0.0747$, and $S_{company\ 2}^{1-} = 0.0619$. For the second expert the following values result: $S_{company\ 1}^{2*} = 0.0645$, $S_{company\ 2}^{2*} = 0.1168$, $S_{company\ 1}^{2-} = 0.1168$, and $S_{company\ 2}^{2-} = 0.0645$. Then, the geometric mean values $\overline{S_i^*}$ and $\overline{S_i^-}$ are calculated to determine the separation measures of the group. These are as follows: $\overline{S_{company\ 1}^*} = 0.0632$, $\overline{S_{company\ 2}^*} = 0.0934$, $\overline{S_{company\ 1}^-} = 0.0934$, and $\overline{S_{company\ 2}^-} = 0.0632$. Afterwards the calculation of the relative closeness $\overline{C_i^*}$ to the ideal solution follows for each alternative. Based on this relative closeness, the alternatives are ranked. In this fictional case study, $\overline{C_{company\ 1}^*} = 0.5966$ and $\overline{C_{company\ 2}^*} = 0.4034$, so company 1 is the preferred alternative and company 2 is the second-ranked alternative. Appendix C shows more details.

4. Discussion of the results

The presented model supports problem identification and problem structuring in the decision-making process for developing and using the SDGSBSC. The solution approach considers the presence of different stakeholder groups represented by experts. Selecting possible BSC indicators for the SDGs is straightforward, as DM members have access to a database on sustainable development reporting. Moreover, DMs can expand this database flexibly as creative processes yield new indicators. As each expert expresses a personal preference about the indicators, an appropriate indicator weighting is possible. It is helpful to consider the organization and the affected stakeholder groups in terms of objectives and priorities during the development process to achieve a balanced result in the interest of all those who are affected by organizational decisions and activities. The computer-aided application of the MCDM processes results in short-time calculations. One advantage of the applications used is their flexible adaptability. One potential criticism is the relatively high effort required to perform pairwise comparisons, which increases significantly as the number of elements to be compared within the network increases. Furthermore, there is a risk of inconsistent results. Therefore, a reasonable clustering or aggregation of the elements is desirable for minimizing effort and ensuring consistency.

5. Implications and future directions

This article has developed a procedural approach to create an SDGSBSC and examined suitable decision-making methods. The possible uses of the SDGSBSC within the organization are extensive due to the top-down approach of the BSC. Cascading is possible from the top management level to the executing entities. Despite the top-down approach, bottom-up feedback may be beneficial to make the goals understandable, agreeable, and realistic for all stakeholders. To answer RQ 1, the approach described above is suitable for organizational sustainability management and the strategic positioning of sustainability in organizations (see section 3.1). It supports organizations in systematically aiming for the SDGs and monitoring the degree of organizational goal achievement regarding these goals. This approach considers the TBL dimensions integratively.

Consequently, the approach addresses the economic, environmental, social, and integration challenges. Moreover, the approach supports organizations in creating added value for stakeholders from a strategic perspective by acting on the improvement of business processes and developing relevant capabilities. This results in organizations leveraging the targeted potential that leads to competitive advantage. Considering stakeholders creates a strong foundation for this. Users can expand the BSC approach to include new perspectives if they desire. ANP and TOPSIS are suitable decision-making methods; thus, RQ 2 is also answered. The chosen MCDM methods allow DM to weigh different alternatives considering a variety of sometimes conflicting criteria and/or experts with different preferences within a DM. The integration of ANP promotes the development of a decision-making structure in a network, which is necessary for connecting the BSC perspectives. Through this, DMs can analyze inner and outer dependencies within the network. This leads to a more accurate representation of real-world problems. The Super Decisions software has provided adequate support for flexible modeling and calculation. TOPSIS is suitable for ranking the alternatives. This ranking is also possible if several experts of a DM shows different preferences.

6. Limitations

Nevertheless, some limitations exist in this article. The approach is limited to SDGs and does not consider further objectives. As soon as the United Nations builds a new consensus within the international state community, researchers and practitioners must examine an expansion of the objectives. It would be interesting to compare the employed methods to other MCDM methods to model network structures and rank alternatives. The modification of aggregation methods may be tested, e.g., by taking a weighted average. In this way, there is the possibility of attributing different importance to experts. For TOPSIS, researchers can use other distance measures, e.g., Manhattan distance or Tchebycheff distance, or normalization methods such as linear normalization to test for possible changes in the results [44]. A criteria evaluation with linguistic term sets leads to the fuzziness problem. An extension by fuzzy set theory may be helpful. This article highlights only a part of the MCDM process (see section 2.3) due to the limited scope of this article. An in-depth elaboration of all components could enrich the approach presented here. A fictional example has validated this approach. Case studies in a real-world context may provide exciting insights.

7. Conclusion

This article proposes a procedure for developing an SDGS-BSC using an ANP-TOPSIS methodology. The approach supports organizations in systematically integrating sustainable development objectives into their corporate strategy and achieving these goals. Consequently, this method supports the guiding principle of sustainable development. It contributes to meeting the needs of present and future generations by systematically deriving measures for the objectives of the SDGs, which are targeted by 2030. Furthermore, the procedure allows for flexible adaptation.

References

[1] World Commission on Environment and Development: editor (**1987**) "Our common future," 1st ed. Oxford, United Kingdom, *Oxford Paperbacks*. 416 p. ISBN: **978-0-19-282080-8**

[2] Costanza R, Daly L, Fioramonti L, Giovannini E, Kubiszewski I, et al. (**2016**) "Modelling and measuring sustainable well-being in connection with the UN Sustainable Development Goals" *Ecol Econ* (vol. 130, pp. 350–355) https://doi.org/10.1016/j.ecolecon.2016.07.009

[3] General Assembly (**2015**) "Transforming our world: The 2030 Agenda for Sustainable Development" New York, USA, *United Nations (UN)*. (https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement) *Accessed*: *18 February **2022***

[4] Pizzi S, Caputo A, Corvino A, Venturelli A (**2020**) "Management research and the UN Sustainable Development Goals (SDGs): A bibliometric investigation and systematic review" *J Clean Prod* (vol. 276, pp. 124033) https://doi.org/10.1016/j.jclepro.2020.124033

[5] Rickels W, Dovern J, Hoffmann J, Quaas MF, Schmidt JO, et al. (**2016**) "Indicators for monitoring Sustainable Development Goals: An application to oceanic development in the European Union" *Earths Future* (vol. 4, no. 5, pp. 252–267) https://doi.org/10.1002/2016EF000353

[6] United Nations (UN) (**2022**) "Global indicator framework for the Sustainable Development Goals and targets of the 2030 agenda for sustainable development" *SDG Indic* (https://unstats.un.org/sdgs/indicators/indicators-list/) *Accessed*: *18 February **2022***

[7] General Assembly (**2017**) "Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development" New York, USA, *United Nations (UN)*. (https://documents-dds-ny.un.org/doc/UNDOC/GEN/N17/207/63/PDF/N1720763.pdf?OpenElement) *Accessed*: *18 February **2022***

[8] Sachs JD (**2012**) "From millennium development goals to Sustainable Development Goals" *The Lancet* (vol. 379, no. 9832, pp. 2206–2211) https://doi.org/10.1016/S0140-6736(12)60685-0

[9] Mio C, Panfilo S, Blundo B (**2020**) "Sustainable development goals and the strategic role of business: A systematic literature review" *Bus Strategy Environ* (vol. 29, no. 8, pp. 3220–3245) https://doi.org/10.1002/bse.2568

[10] Kaplan RS, Norton DP (**1996**) "The balanced scorecard: Translating strategy into action," 1st ed. Massachusetts, United States, *Harvard Business Review Press*. 336 p. ISBN: **978-0-87584-651-4**

[11] Figge F, Hahn T, Schaltegger S, Wagner M (**2002**) "The sustainability balanced scorecard - linking sustainability management to business strategy" *Bus Strategy Environ* (vol. 11, no. 5, pp. 269–284) https://doi.org/10.1002/bse.339

[12] Mook L (**2019**) "The Sustainable Development Goals: A tipping point for impact measurement?" *Can J Nonprofit Soc Econ Res* (vol. 10, no. 2, pp. 81–89) https://doi.org/10.29173/cjnser.2019v10n2a343

[13] Mook L (**2020**) "Performance management, impact measurement and the sustainable development goals: The fourth wave of integrated social accounting?" *Can J Nonprofit Soc Econ Res* (vol. 11, no. 2, pp. 15–15) https://doi.org/10.29173/cjnser.2020v11n2a353

[14] Pereira Ribeiro JM, da Silva SA, da Silva Neiva S, Soares T, Montenegro C, et al. (**2021**) "A proposal of a balanced scorecard to the water, energy and food nexus approach: Brazilian food policies in the context of sustainable development goals" *Stoch Environ Res Risk Assess* (vol. 35, no. 1, pp. 129–146) https://doi.org/10.1007/s00477-020-01769-1

[15] Sarkar S, Singh P (**2019**) "Strategising CSR in addressing sustainable development goals using a scorecard approach" *World Rev Sci Technol Sustain Dev* (vol. 15, no. 4, pp. 313–329) https://doi.org/10.1504/WRSTSD.2019.104095

[16] Köksalan M, Wallenius J, Zionts S (**2016**) "An early history of multiple criteria decision making" In: *Greco S, Ehrgott M, Figueira JR - editors*. Multiple criteria decision analysis: State of the art surveys New York, USA, *Springer* - pp. 3–17. https://doi.org/10.1007/978-1-4939-3094-4_1

[17] Zavadskas EK, Turskis Z, Kildienė S (**2014**) "State of art surveys of overviews on MCDM/MADM methods" *Technol Econ Dev Econ* (vol. 20, no. 1, pp. 165–179) https://doi.org/10.3846/20294913.2014.892037

[18] Greco S, Ehrgott M, Figueira JR (**2005**) "Multiple criteria decision analysis: State of the art surveys," 1st e. New York, USA, *Springer New York*. 1048 p. ISBN: **978-0-387-23081-8** (https://link.springer.com/book/10.1007/978-1-4939-3094-4) *Accessed*: *18 February **2022***

[19] Eisenführ F, Weber M, Langer T (**2010**) “Rational decision making,” 1st ed. Berlin, Germany, *Springer Berlin*. 447 p.

ISBN: **978-3-642-02850-2** (https://link.springer.com/book/9783642028526) *Accessed*: *18 February* ***2022***

[20] Marshall JD, Toffel MW (**2005**) "Framing the elusive concept of sustainability: A sustainability hierarchy" *Environ Sci Technol* (vol. 39, no. 3, pp. 673–682) https://doi.org/10.1021/es040394k

[21] Dyllick T, Hockerts K (**2002**) "Beyond the business case for corporate sustainability" *Bus Strategy Environ* (vol. 11, no. 2, pp. 130–141) https://doi.org/10.1002/bse.323

[22] Elkington J (**1997**) "Cannibals with forks: The triple bottom line of 21st century business," 1st ed. Minnesota, United States, *Capstone Publishing Ltd*. 407 p. ISBN: **978-1-900961-27-1**

[23] Idowu SO, Capaldi N, Zu L, Gupta AD (**2013**) "Encyclopedia of corporate social responsibility," 1st ed. Heidelberg, Germany, *Springer Berlin*. 2772 p. ISBN: **978-3-642-28035-1** (https://link.springer.com/book/10.1007/978-3-642-28036-8) *Accessed*: *18 February* ***2022***

[24] Nzila C, Dewulf J, Spanjers H, Tuigong D, Kiriamiti H, et al. (**2012**) "Multi criteria sustainability assessment of biogas production in Kenya" *Appl Energy* (vol. 93, pp. 496–506) https://doi.org/10.1016/j.apenergy.2011.12.020

[25] Guangdong Wu, Duan K, Zuo J, Zhao X, Tang D (**2017**) "Integrated sustainability assessment of public rental housing community based on a hybrid method of AHP-entropy weight and cloud model" *Sustainability* (vol. 9, no. 4, pp. 603) https://doi.org/10.3390/su9040603

[26] Lozano R (**2008**) "Envisioning sustainability three-dimensionally" *J Clean Prod* (vol. 16, no. 17, pp. 1838–1846) https://doi.org/10.1016/j.jclepro.2008.02.008

[27] Dalal-Clayton B, Bass S (**2002**) "Sustainable Development Strategies: A resource book," 1st ed. Virginia, USA, *Routledge*. 384 p. ISBN: **978-1-85383-947-4**

[28] Schaltegger S, Burritt R, Petersen H (**2003**) "An introduction to corporate environmental management: Striving for sustainability," 1st ed. Sheffield, United Kingdom, *Greenleaf Publishing Ltd*. 384 p. ISBN: **1-874719-65-9**

[29] Epstein MJ, Wisner PS (**2001**) "Using a balanced scorecard to implement sustainability" *Environ Qual Manag* (vol. 11, no. 2, pp. 1–10) https://doi.org/10.1002/tqem.1300

[30] Freeman RE, Reed DL (**1983**) "Stockholders and stakeholders: A new perspective on corporate governance" *Calif Manage Rev* (vol. 25, no. 3, pp. 88–106) https://doi.org/10.2307/41165018

[31] Mio C, Costantini A, Panfilo S (**2022**) "Performance measurement tools for sustainable business: A systematic literature review on the sustainability balanced scorecard use" *Corp Soc Responsib Environ Manag* (vol. 29, no. 2, pp. 367–384) https://doi.org/10.1002/csr.2206

[32] Belton V, Stewart TJ (**2002**) "Multiple criteria decision analysis:An integrated approach," 1st ed. New York, USA, *Springer New York*. 372 p. ISBN: **978-1-4615-1495-4** (https://link.springer.com/book/10.1007/978-1-4615-1495-4)

[33] Korhonen P, Moskowitz H, Wallenius J (**1992**) "Multiple criteria decision support - A review" *Eur J Oper Res* (vol. 63, no. 3, pp. 361–375) https://doi.org/10.1016/0377-2217(92)90155-3

[34] Hwang C-L, Yoon K (**1981**) "Multiple attribute decision making," 1st ed. Heidelberg, Germany, *Springer Berlin*. 269 p. ISBN: **978-3-642-48318-9** (https://link.springer.com/book/10.1007/978-3-642-48318-9) *Accessed*: *18 February* ***2022***

[35] Triantaphyllou E (**2000**) "Multi-criteria decision making methods: A comparative study," 1st ed. New York, USA, *Springer New York*. 290 p. ISBN: **978-1-4757-3157-6** (https://link.springer.com/book/10.1007/978-1-4757-3157-6) *Accessed*: *18 February* ***2022***

[36] Cristóbal Mateo JRS (**2012**) "Multi criteria analysis in the renewable energy industry" London, United Kingdom, *Springer London*. 106 p. ISBN: **978-1-4471-2345-3** (https://link.springer.com/book/10.1007/978-1-4471-2346-0)

[37] Kumar A, Sah B, Singh AR, Deng Y, He X, et al. (**2017**) "A review of multi criteria decision making (MCDM) towards sustainable renewable energy development" *Renew Sustain Energy Rev* (vol. 69, pp. 596–609) https://doi.org/10.1016/j.rser.2016.11.191

[38] Saaty TL (**2006**) "The analytic network process" In: *Saaty TL, Vargas LG - editors*. Decision Making with the Analytic Network Process: Economic, Political, Social and Technological Applications with Benefits, Opportunities, Costs and Risks Massachusetts, USA, *Springer US* - pp. 1–26. https://doi.org/10.1007/0-387-33987-6_1 (https://doi.org/10.1007/0-387-33987-6_1) *Accessed*: *18 February* ***2022***

[39] Saaty TL, Takizawa M (**1986**) "Dependence and independence: From linear hierarchies to nonlinear networks" *Eur J Oper Res* (vol. 26, no. 2, pp. 229–237) https://doi.org/10.1016/0377-2217(86)90184-0

[40] Saaty TL (**2016**) "The analytic hierarchy and analytic network processes for the measurement of intangible criteria and for decision-making" In: *Greco S, Ehrgott M, Figueira JR - editors*. Multiple criteria decision analysis: State of the art surveys New York, USA, *Springer New York* - pp. 363–419. https://doi.org/10.1007/978-1-4939-3094-4_10 (https://doi.org/10.1007/978-1-4939-3094-4_10) *Accessed*: *18 February* ***2022***

[41] Saaty RW (**2016**) "Decision making in complex environments: The Analytic Network Process (ANP) for dependence and feedback," 1st ed. Florida, USA, *Rozann W. Saaty*. 187 p. ISBN: **1-888603-00-3** (https://www.superdecisions.com/sd_resources/v28_man02.pdf)

[42] Blockus M-O (**2010**) "Komplexität in Dienstleistungsunternehmen: Komplexitätsformen, Kosten- und Nutzenwirkungen, empirische Befunde und Managementimplikationen," 1st ed. Wiesbaden, Germany, *Gabler Verlag Wiesbaden*. 353 p. ISBN: **978-3-8349-8958-1** (https://link.springer.com/book/10.1007/978-3-8349-8958-1) *Accessed*: *18 February* ***2022***

[43] Chen S-J, Hwang C-L (**1992**) "Fuzzy multiple attribute decision making: methods and applications," 1st ed. Heidelberg, Germany, *Springer Berlin*. 536 p. ISBN: **978-3-642-46768-4** (https://link.springer.com/book/10.1007/978-3-642-46768-4)

[44] Shih H-S, Shyur H-J, Lee ES (**2007**) "An extension of TOPSIS for group decision making" *Math Comput Model* (vol. 45, no. 7, pp. 801–813) https://doi.org/10.1016/j.mcm.2006.03.023

[45] GRI, UN Global Compact, and WBCSD (n.d.) "Inventory of business indicators" *SDG Compass* (https://sdgcompass.org/business-indicators/) *Accessed: 15 February* ***2022***

[46] Niemira MP, Saaty TL (**2006**) "An analytic network process model for financial-crisis forecasting" In: *Saaty TL, Vargas LG - editors.* Decision making with the analytic network process: Economic, political, social and technological applications with benefits, opportunities, costs and risks Massachusetts, USA, *Springer US* - pp. 45–61. https://doi.org/10.1007/0-387-33987-6_3 (https://doi.org/10.1007/0-387-33987-6_3) *Accessed: 18 February* ***2022***

Appendix A

A1. Pairwise comparisons of the first expert

Node comparisons with respect to OV (cluster: perspectives)

Table 3: Perspective weights given by the first expert with respect to OV.

Name	Normalized	Idealized	Inconsistency: 0.0172
P1	0.2879	0.6419	
P2	0.1258	0.2804	
P3	0.1377	0.3069	
P4	0.4486	1.0000	

Table 4: Comparison matrix of perspectives by the first expert with respect to OV.

	P1	P2	P3	P4
P1	1.0000	3.0000	2.0000	0.5000
P2	0.3333	1.0000	1.0000	0.3333
P3	0.5000	1.0000	1.0000	0.3333
P4	2.0000	3.0000	3.0000	1.0000

Node comparisons with respect to P1 (cluster: perspectives)

Table 5: Perspective weights given by the first expert with respect to P1.

Name	Normalized	Idealized	Inconsistency: 0.0176
P2	0.3874	0.8736	
P3	0.1692	0.3816	
P4	0.4434	1.0000	
P4	0.4434	1.0000	

Table 6: Comparison matrix of perspectives by the first expert with respect to P1.

	P2	P3	P4
P2	1.0000	2.0000	1.0000
P3	0.5000	1.0000	0.3333
P4	1.0000	3.0000	1.0000

Node comparisons with respect to P1 (cluster: strategies)

Table 7: Strategy weights given by the first expert with respect to P1.

Name	Normalized	Idealized	Inconsistency: 0.0237
S1	0.6833	1.0000	
S2	0.1998	0.2924	
S3	0.1168	0.1710	

Table 8: Comparison matrix of strategies by the first expert with respect to P1.

	S1	S2	S3
S1	1.0000	4.0000	5.0000
S2	0.2500	1.0000	2.0000
S3	0.2000	0.5000	1.0000

Node comparisons with respect to P2 (cluster: perspectives)

Table 9: Perspective weights are given by the first expert with respect to P2.

Name	Normalized	Idealized	Inconsistency: 0.0516
P1	0.3325	0.6300	
P3	0.5278	1.0000	
P4	0.1396	0.2646	

Table 10: Comparison matrix of perspectives by the first expert with respect to P2.

	P1	P3	P4
P1	1.0000	0.5000	3.0000
P3	2.0000	1.0000	3.0000
P4	0.3333	0.3333	1.0000

Node comparisons with respect to P2 (cluster: strategies)

Table 11: Strategy weights given by the first expert with respect to P2.

Name	Normalized	Idealized	Inconsistency: 0.0176
S1	0.5584	1.0000	
S2	0.3196	0.5724	
S3	0.1220	0.2184	

Table 12: Comparison matrix of strategies by the first expert with respect to P2.

	S1	S2	S3
S1	1.0000	2.0000	4.0000
S2	0.5000	1.0000	3.0000
S3	0.2500	0.3333	1.0000

Node comparisons with respect to P3 (cluster: perspectives)

Table 13: Perspective weights given by the first expert with respect to P3.

Name	Normalized	Idealized	Inconsistency: 0.0089
P1	0.5396	1.0000	
P2	0.2970	0.5503	
P4	0.1634	0.3029	

Table 14: Comparison matrix of perspectives by the first expert with respect to P3.

	P1	P2	P4
P1	1.0000	2.0000	3.0000
P2	0.5000	1.0000	2.0000
P4	0.3333	0.5000	1.0000

Node comparisons with respect to P3 (cluster: strategies)

Table 15: Strategy weights given by the first expert with respect to P3.

Name	Normalized	Idealized	Inconsistency: 0.0516
S1	0.1958	0.3969	
S2	0.3108	0.6300	
S3	0.4934	1.0000	

Table 16: Comparison matrix of strategies by the first expert with respect to P3.

	S1	S2	S3
S1	1.0000	0.5000	0.5000
S2	2.0000	1.0000	0.5000
S3	2.0000	2.0000	1.0000

Node comparisons with respect to P4 (cluster: perspectives)

Table 17: Perspective weights given by the first expert with respect to P4.

Name	Normalized	Idealized	Inconsistency: 0.0516
P1	0.1396	0.2646	
P2	0.3325	0.6300	
P3	0.5278	1.0000	

Table 18: Comparison matrix of perspectives by the first expert with respect to P4.

	P1	P2	P3
P1	1.0000	0.3333	0.3333
P2	3.0000	1.0000	0.5000
P3	3.0000	2.0000	1.0000

Node comparisons with respect to P4 (cluster: strategies)

Table 19: Strategy weights given by the first expert with respect to P4.

Name	Normalized	Idealized	Inconsistency: 0.0000
S1	0.2000	0.5000	
S2	0.4000	1.0000	
S3	0.4000	1.0000	

Table 20: Comparison matrix of strategies by the first expert with respect to P4.

	S1	S2	S3
S1	1.0000	0.5000	0.5000
S2	2.0000	1.0000	1.0000
S3	2.0000	1.0000	1.0000

Node comparisons with respect to S1 (cluster: SDGs)

Table 21: SDG weights given by the first expert with respect to S1.

Name	Normalized	Idealized	Inconsistency: 0.0442
G4	0.1818	0.3805	
G8	0.2352	0.4922	
G9	0.4778	1.0000	

Table 22: Comparison matrix of SDGs by the first expert with respect to S1.

	G4	G8	G9	G17
G4	1.0000	0.5000	0.5000	2.0000
G8	2.0000	1.0000	0.3333	2.0000
G9	2.0000	3.0000	1.0000	4.0000
G17	0.5000	0.5000	0.2500	1.0000

Node comparisons with respect to S2 (cluster: SDGs)

Table 23: SDG weights given by the first expert with respect to S2.

Name	Normalized	Idealized	Inconsistency: 0.0487
G6	0.0619	0.1931	
G7	0.1197	0.3737	
G11	0.1395	0.4354	
G12	0.3204	1.0000	
G13	0.2091	0.6525	
G14	0.0747	0.2332	
G15	0.0747	0.2332	

Table 24: Comparison matrix of SDGs by the first expert with respect to S2.

	G6	G7	G11	G12	G13	G14	G15
G6	1.0000	0.3333	0.5000	0.3333	0.5000	0.5000	0.5000
G7	3.0000	1.0000	0.5000	0.3333	0.5000	2.0000	2.0000
G11	2.0000	2.0000	1.0000	0.5000	0.3333	2.0000	2.0000
G12	3.0000	3.0000	2.0000	1.0000	3.0000	4.0000	4.0000
G13	2.0000	2.0000	3.0000	0.3333	1.0000	3.0000	3.0000
G14	2.0000	0.5000	0.5000	0.2500	0.3333	1.0000	1.0000
G15	2.0000	0.5000	0.5000	0.2500	0.3333	1.0000	1.0000

Node comparisons with respect to S3 (cluster: SDGs)

Table 25: SDG weights given by the first expert with respect to S3.

Name	Normalized	Idealized	Inconsistency: 0.0651
G1	0.2379	1.0000	
G2	0.2379	1.0000	
G3	0.1224	0.5147	
G5	0.1264	0.5315	
G10	0.1264	0.5315	
G16	0.1489	0.6257	

Table 26: Comparison matrix of SDGs by the first expert with respect to S3.

	G1	G2	G3	G5	G10	G16
G1	1.0000	1.0000	2.0000	2.0000	2.0000	2.0000
G2	1.0000	1.0000	2.0000	2.0000	2.0000	2.0000
G3	0.5000	0.5000	1.0000	0.5000	0.5000	2.0000
G5	0.5000	0.5000	2.0000	1.0000	1.0000	0.5000
G10	0.5000	0.5000	2.0000	1.0000	1.0000	0.5000
G16	0.5000	0.5000	0.5000	2.0000	2.0000	1.0000

A2. Pairwise comparisons of the second expert

Node comparisons with respect to OV (cluster: perspectives)

Table 27: Perspective weights given by the second expert with respect to OV.

Name	Normalized	Idealized	Inconsistency: 0.0328
P1	0.4583	1.0000	
P2	0.1733	0.3781	
P3	0.0792	0.1729	
P4	0.2891	0.6308	

Table 28: Comparison matrix of perspectives by the second expert with respect to OV.

	P1	P2	P3	P4
P1	1.0000	3.0000	4.0000	2.0000
P2	0.3333	1.0000	3.0000	0.5000
P3	0.2500	0.3333	1.0000	0.2500
P4	0.5000	2.0000	4.0000	1.0000

Node comparisons with respect to P1 (cluster: perspectives)

Table 29: Perspective weights given by the second expert with respect to P1.

Name	Normalized	Idealized	Inconsistency: 0.0176
P2	0.6250	1.0000	
P3	0.1365	0.2184	
P4	0.2385	0.3816	

Table 30: Comparison matrix of perspectives by the second expert with respect to P1.

	P2	P3	P4
P2	1.0000	4.0000	3.0000
P3	0.2500	1.0000	0.5000
P4	0.3333	2.0000	1.0000

Node comparisons with respect to P1 (cluster: strategies)

Table 31: Strategy weights given by the second expert with respect to P1.

Name	Normalized	Idealized	Inconsistency: 0.0000
S1	0.7143	1.0000	
S2	0.1429	0.2000	
S3	0.1429	0.2000	

Table 32: Comparison matrix of strategies by the second expert with respect to P1.

	S1	S2	S3
S1	1.0000	5.0000	5.0000
S2	0.2000	1.0000	1.0000
S3	0.2000	1.0000	1.0000

Node comparisons with respect to P2 (cluster: perspectives)

Table 33: Perspective weights given by the second expert with respect to P2.

Name	Normalized	Idealized	Inconsistency: 0.0089
P1	0.1634	0.3029	
P3	0.5396	1.0000	
P4	0.2970	0.5503	

Table 34: Comparison matrix of perspectives by the second expert with respect to P2.

	P1	P3	P4
P1	1.0000	0.3333	0.5000
P3	3.0000	1.0000	2.0000
P4	2.0000	0.5000	1.0000

Node comparisons with respect to P2 (cluster: strategies)

Table 35: Strategy weights given by the second expert with respect to P2.

Name	Normalized	Idealized	Inconsistency: 0.0000
S1	0.5000	1.0000	
S2	0.2500	0.5000	
S3	0.2500	0.5000	

Table 36: Comparison matrix of strategies by the second expert with respect to P2.

	S1	S2	S3
S1	1.0000	2.0000	2.0000
S2	0.5000	1.0000	1.0000
S3	0.5000	1.0000	1.0000

Node comparisons with respect to P3 (cluster: perspectives)

Table 37: Perspective weights given by the second expert with respect to P3.

Name	Normalized	Idealized	Inconsistency: 0.0089
P1	0.2000	0.2752	
P2	0.7267	1.0000	
P4	0.0734	0.1010	

Table 38: Comparison matrix of perspectives by the second expert with respect to P3.

	P1	P2	P4
P1	1.0000	0.2500	3.0000
P2	4.0000	1.0000	9.0000
P4	0.3333	0.1111	1.0000

Node comparisons with respect to P3 (cluster: strategies)

Table 39: Strategy weights given by the second expert with respect to P3.

Name	Normalized	Idealized	Inconsistency: 0.0516
S1	0.2081	0.3150	
S2	0.1311	0.1984	
S3	0.6608	1.0000	

Table 40: Table 40: Comparison matrix of strategies by the second expert with respect to P3.

	S1	S2	S3
S1	1.0000	2.0000	0.2500
S2	0.5000	1.0000	0.2500
S3	4.0000	4.0000	1.0000

Node comparisons with respect to P4 (cluster: perspectives)

Table 41: Perspective weights given by the second expert with respect to P4.

Name	Normalized	Idealized	Inconsistency: 0.0825
P1	0.6738	1.0000	
P2	0.1007	0.1494	
P3	0.2255	0.3347	

Table 42: Comparison matrix of perspectives by the second expert with respect to P4.

	P1	P2	P3
P1	1.0000	5.0000	4.0000
P2	0.2000	1.0000	0.3333
P3	0.2500	3.0000	1.0000

Node comparisons with respect to P4 (cluster: strategies)

Table 43: Strategy weights given by the second expert with respect to P4.

Name	Normalized	Idealized	Inconsistency: 0.0176
S1	0.1220	0.2184	
S2	0.5584	1.0000	
S3	0.3196	0.5724	

Table 44: Comparison matrix of strategies by the second expert with respect to P4.

	S1	S2	S3
S1	1.0000	0.2500	0.3333
S2	4.0000	1.0000	2.0000
S3	3.0000	0.5000	1.0000

Node comparisons with respect to S1 (cluster: SDGs)

Table 45: SDG weights given by the second expert with respect to S1.

Name	Normalized	Idealized	Inconsistency: 0.0941
G4	0.0810	0.2015	
G8	0.1821	0.4531	
G9	0.4018	1.0000	
G17	0.3352	0.8342	

Table 46: Comparison matrix of SDGs by the second expert with respect to S1.

	G4	G8	G9	G17
G4	1.0000	0.2500	0.3333	0.2500
G8	4.0000	1.0000	0.2500	0.5000
G9	3.0000	4.0000	1.0000	1.0000
G17	4.0000	2.0000	1.0000	1.0000

Node comparisons with respect to S2 (cluster: SDGs)

Table 47: SDG weights given by the second expert with respect to S2.

Name	Normalized	Idealized	Inconsistency: 0.1560
G6	0.1641	0.5920	
G7	0.1094	0.3945	
G11	0.0342	0.1235	
G12	0.1193	0.4305	
G13	0.2772	1.0000	
G14	0.1611	0.5812	
G15	0.1346	0.4856	

Table 48: Comparison matrix of SDGs by the second expert with respect to S2.

	G6	G7	G11	G12	G13	G14	G15
G6	1.0000	3.0000	4.0000	0.3333	0.2500	3.0000	1.0000
G7	0.3333	1.0000	3.0000	2.0000	1.0000	0.3333	0.5000
G11	0.2500	0.3333	1.0000	0.3333	0.1667	0.2500	0.3333
G12	3.0000	0.5000	3.0000	1.0000	0.2500	0.5000	0.5000
G13	4.0000	1.0000	6.0000	4.0000	1.0000	1.0000	3.0000
G14	0.3333	3.0000	4.0000	2.0000	1.0000	1.0000	1.0000
G15	1.0000	2.0000	3.0000	2.0000	0.3333	1.0000	1.0000

Node comparisons with respect to S3 (cluster: SDGs)

Table 49: SDG weights given by the second expert with respect to S3.

Name	Normalized	Idealized	Inconsistency: 0.0452
G1	0.1911	0.6132	
G2	0.2920	0.9368	
G3	0.3117	1.0000	
G5	0.0684	0.2196	
G10	0.0645	0.2070	
G16	0.0723	0.2320	

Table 50: Comparison matrix of SDGs by the second expert with respect to S3.

	G1	G2	G3	G5	G10	G16
G1	1.0000	0.3333	0.5000	4.0000	3.0000	4.0000
G2	3.0000	1.0000	0.5000	4.0000	5.0000	3.0000
G3	2.0000	2.0000	1.0000	3.0000	4.0000	3.0000
G5	0.2500	0.2500	0.3333	1.0000	1.0000	1.0000
G10	0.3333	0.2000	0.2500	1.0000	1.0000	1.0000
G16	0.2500	0.3333	0.3333	1.0000	1.0000	1.0000

Appendix B

Table 51: Element weights given by each expert.

	First Expert		Second Expert	
	Normalized By Cluster	Limiting	Normalized By Cluster	Limiting
P1	0.2648	0.0331	0.2251	0.0281
P2	0.2529	0.0316	0.3443	0.0430
P3	0.2833	0.0354	0.2559	0.0320
P4	0.1990	0.0249	0.1747	0.0218
S1	0.4174	0.0522	0.4075	0.0509
S2	0.3014	0.0377	0.2493	0.0312
S3	0.2812	0.0351	0.3432	0.0429
G1	0.0669	0.0167	0.0656	0.0164
G2	0.0669	0.0167	0.1002	0.0250
G3	0.0344	0.0086	0.1070	0.0267
G4	0.0759	0.0190	0.0330	0.0082
G5	0.0356	0.0089	0.0235	0.0059
G6	0.0187	0.0047	0.0409	0.0102
G7	0.0361	0.0090	0.0273	0.0068
G8	0.0982	0.0245	0.0742	0.0185
G9	0.1995	0.0499	0.1637	0.0409
G10	0.0356	0.0089	0.0221	0.0055
G11	0.0420	0.0105	0.0085	0.0021
G12	0.0966	0.0241	0.0298	0.0074
G13	0.0630	0.0158	0.0691	0.0173
G14	0.0225	0.0056	0.0402	0.0100
G15	0.0225	0.0056	0.0336	0.0084
G16	0.0419	0.0105	0.0248	0.0062
G17	0.0439	0.0110	0.1366	0.0341

Table 52: Element weights given by each expert (continued).

	First Expert		Second Expert	
	Normalized By Cluster	Limiting	Normalized By Cluster	Limiting
I1.1	0.0669	0.0334	0.0656	0.0328
I2.1	0.0669	0.0334	0.1002	0.0501
I3.1	0.0344	0.0172	0.1070	0.0535
I4.1	0.0759	0.0379	0.0330	0.0165
I5.1	0.0356	0.0178	0.0235	0.0117
I6.1	0.0187	0.0093	0.0409	0.0205
I7.1	0.0361	0.0180	0.0273	0.0136
I8.1	0.0982	0.0491	0.0742	0.0371
I9.1	0.1995	0.0997	0.1637	0.0819
I10.1	0.0356	0.0178	0.0221	0.0111
I11.1	0.0420	0.0210	0.0085	0.0043
I12.1	0.0966	0.0483	0.0298	0.0149
I13.1	0.0630	0.0315	0.0691	0.0346
I14.1	0.0225	0.0113	0.0402	0.0201
I15.1	0.0225	0.0113	0.0336	0.0168
I16.1	0.0419	0.0209	0.0248	0.0124
I17.1	0.0439	0.0220	0.1366	0.0683

Table 53: Element weights used for TOPSIS.

	First expert	Second expert	Geometric Mean	Geometric Mean
	Normalized By Cluster	Normalized By Cluster	Aggregated	Aggregated & Normalized
I1.1	0.0669	0.0656	0.0662	0.0700
I2.1	0.0669	0.1002	0.0819	0.0865
I3.1	0.0344	0.1070	0.0607	0.0641
I4.1	0.0759	0.0330	0.0500	0.0529
I5.1	0.0356	0.0235	0.0289	0.0305
I6.1	0.0187	0.0409	0.0276	0.0292
I7.1	0.0361	0.0273	0.0314	0.0331
I8.1	0.0982	0.0742	0.0853	0.0902
I9.1	0.1995	0.1637	0.1807	0.1909
I10.1	0.0356	0.0221	0.0281	0.0296
I11.1	0.0420	0.0085	0.0189	0.0200
I12.1	0.0966	0.0298	0.0536	0.0566
I13.1	0.0630	0.0691	0.0660	0.0697
I14.1	0.0225	0.0402	0.0301	0.0318
I15.1	0.0225	0.0336	0.0275	0.0290
I16.1	0.0419	0.0248	0.0322	0.0340
I17.1	0.0439	0.1366	0.0774	0.0818
$\sum$	1.0000	1.0000	0.9466	1.0000

Appendix C

C1. Initial data for TOPSIS

Table 54: Initial data of the first and second expert.

1st Expert	Company 1	Company 2	2nd Expert	Company 1	Company 2
I1.1	2.0000	1.0000	I1.1	2.0000	2.0000
I2.1	3.0000	2.0000	I2.1	3.0000	1.0000
I3.1	1.0000	3.0000	I3.1	1.0000	2.0000
I4.1	2.0000	2.0000	I4.1	3.0000	1.0000
I5.1	2.0000	3.0000	I5.1	2.0000	3.0000
I6.1	2.0000	2.0000	I6.1	2.0000	2.0000
I7.1	2.0000	3.0000	I7.1	2.0000	1.0000
I8.1	1.0000	3.0000	I8.1	1.0000	3.0000
I9.1	3.0000	3.0000	I9.1	2.0000	1.0000
I10.1	3.0000	1.0000	I10.1	3.0000	2.0000
I11.1	2.0000	3.0000	I11.1	2.0000	2.0000
I12.1	2.0000	1.0000	I12.1	2.0000	2.0000
I13.1	2.0000	1.0000	I13.1	2.0000	1.0000
I14.1	2.0000	2.0000	I14.1	2.0000	3.0000
I15.1	3.0000	2.0000	I15.1	2.0000	1.0000
I16.1	1.0000	2.0000	I16.1	1.0000	2.0000
I17.1	2.0000	3.0000	I17.1	2.0000	3.0000

C2. Normalized decision matrices

Table 55: Normalized decision matrices of the first expert and second expert.

1st Expert	Company 1	Company 2	2nd Expert	Company 1	Company 2
I1.1	0.8944	0.4472	I1.1	0.7071	0.7071
I2.1	0.8321	0.5547	I2.1	0.9487	0.3162
I3.1	0.3162	0.9487	I3.1	0.4472	0.8944
I4.1	0.7071	0.7071	I4.1	0.9487	0.3162
I5.1	0.5547	0.8321	I5.1	0.5547	0.8321
I6.1	0.7071	0.7071	I6.1	0.7071	0.7071
I7.1	0.5547	0.8321	I7.1	0.8944	0.4472
I8.1	0.3162	0.9487	I8.1	0.3162	0.9487
I9.1	0.7071	0.7071	I9.1	0.8944	0.4472
I10.1	0.9487	0.3162	I10.1	0.8321	0.5547
I11.1	0.5547	0.8321	I11.1	0.7071	0.7071
I12.1	0.8944	0.4472	I12.1	0.7071	0.7071
I13.1	0.8944	0.4472	I13.1	0.8944	0.4472
I14.1	0.7071	0.7071	I14.1	0.5547	0.8321
I15.1	0.8321	0.5547	I15.1	0.8944	0.4472
I16.1	0.4472	0.8944	I16.1	0.4472	0.8944
I17.1	0.5547	0.8321	I17.1	0.5547	0.8321

C3. Weighted normalized decision matrices

Table 56: Weighted normalized decision matrix of the first expert and second expert.

1st Expert	weights	Company 1	Company 2	2nd Expert	weights	Company 1	Company 2
I1.1	0.0700	0.0626	0.0313	I1.1	0.0700	0.0495	0.0495
I2.1	0.0865	0.0720	0.0480	I2.1	0.0865	0.0820	0.0273
I3.1	0.0641	0.0203	0.0608	I3.1	0.0641	0.0287	0.0573
I4.1	0.0529	0.0374	0.0374	I4.1	0.0529	0.0501	0.0167
I5.1	0.0305	0.0169	0.0254	I5.1	0.0305	0.0169	0.0254
I6.1	0.0292	0.0206	0.0206	I6.1	0.0292	0.0206	0.0206
I7.1	0.0331	0.0184	0.0276	I7.1	0.0331	0.0296	0.0148
I8.1	0.0902	0.0285	0.0855	I8.1	0.0902	0.0285	0.0855
I9.1	0.1909	0.1350	0.1350	I9.1	0.1909	0.1708	0.0854
I10.1	0.0296	0.0281	0.0094	I10.1	0.0296	0.0247	0.0164
I11.1	0.0200	0.0111	0.0166	I11.1	0.0200	0.0141	0.0141
I12.1	0.0566	0.0507	0.0253	I12.1	0.0566	0.0400	0.0400
I13.1	0.0697	0.0624	0.0312	I13.1	0.0697	0.0624	0.0312
I14.1	0.0318	0.0225	0.0225	I14.1	0.0318	0.0176	0.0264
I15.1	0.0290	0.0242	0.0161	I15.1	0.0290	0.0260	0.0130
I16.1	0.0340	0.0152	0.0305	I16.1	0.0340	0.0152	0.0305
I17.1	0.0818	0.0454	0.0681	I17.1	0.0818	0.0454	0.0681

C4. Ideal and negative-ideal solutions and separation measures

Table 57: Ideal and negative-ideal solutions and separation measures of the first expert.

1st Expert	B/C	Company 1	Company 2	v_j^*	v_j^-
I1.1	B	0.0626	0.0313	0.0626	0.0313
I2.1	B	0.0720	0.0480	0.0720	0.0480
I3.1	C	0.0203	0.0608	0.0203	0.0608
I4.1	B	0.0374	0.0374	0.0374	0.0374
I5.1	C	0.0169	0.0254	0.0169	0.0254
I6.1	B	0.0206	0.0206	0.0206	0.0206
I7.1	C	0.0184	0.0276	0.0184	0.0276
I8.1	B	0.0285	0.0855	0.0855	0.0285
I9.1	B	0.1350	0.1350	0.1350	0.1350
I10.1	B	0.0281	0.0094	0.0281	0.0094
I11.1	C	0.0111	0.0166	0.0111	0.0166
I12.1	B	0.0507	0.0253	0.0507	0.0253
I13.1	B	0.0624	0.0312	0.0624	0.0312
I14.1	C	0.0225	0.0225	0.0225	0.0225
I15.1	C	0.0242	0.0161	0.0161	0.0242
I16.1	C	0.0152	0.0305	0.0152	0.0305
I17.1	B	0.0454	0.0681	0.0681	0.0454
S_i^*	-	0.0619	0.0747		
S_i^-	-	0.0747	0.0619		

Table 58: Ideal and negative-ideal solutions and separation measures of the second expert.

2nd Expert	B/C	Company 1	Company 2	v_j^*	v_j^-
I1.1	B	0.0495	0.0495	0.0495	0.0495
I2.1	B	0.0820	0.0273	0.0820	0.0273
I3.1	C	0.0287	0.0573	0.0287	0.0573
I4.1	B	0.0501	0.0167	0.0501	0.0167
I5.1	C	0.0169	0.0254	0.0169	0.0254
I6.1	B	0.0206	0.0206	0.0206	0.0206
I7.1	C	0.0296	0.0148	0.0148	0.0296
I8.1	B	0.0285	0.0855	0.0855	0.0285
I9.1	B	0.1708	0.0854	0.1708	0.0854
I10.1	B	0.0247	0.0164	0.0247	0.0164
I11.1	C	0.0141	0.0141	0.0141	0.0141
I12.1	B	0.0400	0.0400	0.0400	0.0400
I13.1	B	0.0624	0.0312	0.0624	0.0312
I14.1	C	0.0176	0.0264	0.0176	0.0264
I15.1	C	0.0260	0.0130	0.0130	0.0260
I16.1	C	0.0152	0.0305	0.0152	0.0305
I17.1	B	0.0454	0.0681	0.0681	0.0454
S_i^*	-	0.0645	0.1168		
S_i^-	-	0.1168	0.0645		

C5. Group separation measures

Table 59: Group separation measures.

Company 1	S_i^*	S_i^-	Company 2	S_i^*	S_i^-
1st Expert	0.0619	0.0747	I1.1	0.0747	0.0619
2nd Expert	0.0645	0.1168	I2.1	0.1168	0.0645
$\overline{S_i^*}$ & $\overline{S_i^-}$	0.0632	0.0934	I17.1	0.0934	0.0632

C6. Relative closeness to the ideal solution

Table 60: Relative closeness to the ideal solution.

	$\overline{S_i^*}$	$\overline{S_i^-}$	$\overline{S_i^*} + \overline{S_i^-}$	C_i^*	Rank
Company 1	0.0632	0.0934	0.1566	0.5966	1
Company 2	0.0934	0.0632	0.1566	0.4034	2