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Article

Developing a Controlling Model for Analyzing the Subjectivity of Enterprise Sustainability and Expert Group Judgments Using Fuzzy Triangular Membership Functions

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Abstract: The evaluation of sustainability is complex, involving several factors and expert opinions. In our research, we analyzed and evaluated the activities of a premium packaging material manufacturer with the participation of three relevant and professional groups. Various expectations have been defined in the form of plan values. From these plan values, we measured and evaluated the sustainability level of the company with the help of plan-fact ratios, fuzzy logic and triangular functions, enabling the subjective evaluation and integration of different opinions into the model. The purpose of our model is to support enterprise decision-making by taking into account sustainability aspects and the different expectations of interested parties. Our model helps identify intervention points and manages subjectivity in the field so that the decisions of enterprise managers better reflect the expectations and perspectives of those involved. The model we built is significantly different from previously used and developed indexes, as it functions as an enterprise-controlling model and index during sustainability evaluation. The developed model can also integrate company-specific and global sustainability indicators. Our research contributes to the development of sustainability evaluation methodology and the scientific examination of enterprise decision-making models. The controlling model we developed offers an integrated approach to managing the subjectivity of sustainability evaluation and the different expectations of stakeholder groups.

Keywords: sustainability index; enterprise performance evaluation; fuzzy logic; modeling; triangular function

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1. Introduction

Enterprise sustainability has received significant attention in the past decades, but especially nowadays, both in the field of theoretical and practical research. However, it can still be stated that measuring the level of enterprise sustainability still receives little attention, despite the fact that it plays a prominent role in the business sphere [1,2]. In the literature, many studies deal with the issue of sustainability from different perspectives, but only a few studies deal with the measurement of enterprise sustainability. The existing studies analyze the measurement of sustainability primarily at the macro level, i.e., for countries, regions, cities or industries [3–9], rather than at the micro level, focusing on an enterprise approach. From a micro perspective, few studies directly examine the application of sustainability practices and their performance evaluation [10]. At the same time, it can be stated that enterprises's investment in sustainable practices leads to an increase in competitiveness in the long term [11]. The direct positive impact on competitiveness appears primarily in the areas of enterprise image, efficiency and marketing [12–14]. However, due to the lack of scientific consensus on the concept and measurement of sustainability, it is difficult to propose a standard measurement method and indicator system that is generally applicable and adequately expresses the level of enterprise sustainability [15]. Therefore, measuring and improving sustainability has become a key factor [16], which today can be seen as a significant competitive factor, but in the near future, as a fundamental criterion [17]. As a result, the importance of sustainability is also recognized by enterprise decision-makers, and for many companies, in addition to market value, sustainable operation is a stakeholder expectation. Hayward et al. (2013) concluded in their study that 93% of enterprise decision-makers consider sustainability important for the future success of their business, while only 38% believe that they can quantify the performance of enterprise sustainability [18]. In order for enterprises to be able to adapt to the sustainable paradigm and to be able to integrate sustainability aspects into their operations, appropriate monitoring is necessary. Therefore, the construction of systems that evaluate the company's sustainability performance is particularly emphasized [15]. However, the methods and systems developed to evaluate the level of enterprise sustainability do not provide a satisfactory evaluation. The reason for this is that there is no generally accepted set of KPIs, so the selection of KPIs during performance evaluation is a subjective process [19]. This significantly affects the ability of performance evaluation systems to provide a holistic view of an enterprise's sustainability performance and identify related improvement points. The performance evaluation of this area is, therefore, a complex task, which results from the lack of a general definition of sustainability and, thus, the difficulty of its measurement. Among the definitions of sustainability, the most common is the one formulated in the Brundtland (2010) report, according to which sustainability is development that meets the needs and requirements of the present without compromising the ability of future generations to meet their own needs [20]. The Manufacturing Institute of Cambridge University formulated the definition of sustainability specifically from an industrial point of view, which defines it as the conceptualization, design and manufacture of goods and services that meet the needs and requirements of the present generation while not diminishing economic, social and environmental opportunity in the long-produce [21]. Based on the definitions, it can be stated that sustainability covers several areas, of which three dimensions should be highlighted (Economic, Social and Environmental), otherwise known as 3P (Profit–Economy, People–Society and Planet–Environmental) or triple bottom line (TBL) [22]. For most enterprises, TBL provides a comprehensive approach to measuring sustainability performance [23]. Therefore, the holistic approach based on TBL is suitable for enterprises to measure sustainability [24]. There is no general consensus on which sub-dimensions and related indicators should be considered relevant when measuring the three dimensions of enterprise sustainability [25].

As a result of the lack of clarity in the definition of sustainability and its measurement, several systems of sustainability evaluation criteria have been developed. One of the development directions of sustainability performance evaluation is performance evaluation based on various reports and the indicators defined in them. These include, for example, the Global Reporting Initiative (GRI), the UN Global Compact (UNGC) or the Sustainable Development Framework—Agenda 2030 report [26]. Another direction of development in performance evaluation is the creation of indexes necessary for sustainability evaluation. Examples include the OECD Core indicators, the NIST Sustainable Production Indicators Database, the Composite Sustainable Development Index (CSDI), the Sustainable Production Index or the Dow Jones Sustainability Indices. The field of application of these indexes is different (process, production, enterprise performance evaluation, etc.), and it focuses on different sustainability dimensions and issues. The reports and indexes developed by various professional organizations can, therefore, often evaluate the sustainability level of enterprises along different plan values, as well as different threshold values and weights. The indicator numbers and the majority of the indexes in the reports typically focus on the analysis of global data; their deficiency is the processing of internal data, which can provide valuable information for decision-makers. Furthermore, some indices can be considered too general; hence, their practical application is not widespread [27]. To solve this problem, Hristov and Chirico (2019) suggest in their study that key performance indicators (KPIs) suitable for measuring sustainability should be defined based on the enterprise strategy [28].

Recognizing the importance of internal data, significant emphasis was placed on the development of integrated performance evaluation models that take into account the three aspects of sustainability (Economic, Social, Environmental) [29,30]. The available data can be seen as a bottleneck in model development. Nowadays, however, the development of IT and data science, especially the use of databases and data processing capabilities created by Big Data and digitization, fundamentally changes the process of performance measurement and decision-making. These developments allow different reports to express the performance of an entire area or organizational unit. The current challenges are placed on the construction of performance evaluation systems, during which one of the most significant tasks is the creation of aggregate indicators and peak indicators formed along different logical connections [31,32]. The creation of such aggregated indicators requires an efficient infrastructure and the use of mathematical and statistical methods. Such complex indicators can be called composite indicators, which is one of the new research areas in the field of enterprise sustainability level evaluation. Composite indicators enable the integration of global and internal data, as well as the integrated evaluation of several aspects expressed in a single index [33–35]. In this way, the sustainability level of the examined organization can be determined more precisely and can be expressed in an indicator. Composite indicators allow the integrated evaluation of several aspects expressed into one single index. The sustainability index can, therefore, be considered as an aggregate peak indicator, which can be used to express and evaluate the sustainability level of the organization under examination in one indicator. Several studies have examined these indices, using different methods and KPIs to evaluate the level of sustainability [36–38]. However, due to the lack of a comprehensive framework of sustainability criteria and a generally accepted sustainability evaluation method, the evaluation by the indices can be considered subjective. The high subjectivity in the field results from the definition of goals, the selection of KPIs, the normalization of KPIs, the creation of aggregates and the weighting of KPIs—aggregates, as well as the evaluation process. However, a significant majority of studies agree that fuzzy logic can be an excellent method for developing and evaluating the sustainability index. One of the main bottlenecks of modeling based on fuzzy logic is the selection of standardized norms and evaluation limits. Many researches take as a basis the professional opinions given by various professional organizations and use them to determine both the standardized norm and the threshold values as membership function values [39–42]. These data are values that can be interpreted as input membership functions of fuzzy models. However, professional organizations only reflect one type of value judgment, and several norms may be necessary to determine an accurate evaluation. Among these standards, the values determined by company managers and controllers can be considered significant too. In addition, in order for such a performance evaluation to adequately support the decision-making of managers, the enterprise goals and capacities are also necessary to take into account. Therefore, enterprise controlling systems must also be capable of monitoring sustainability aspects, and for this purpose, performance evaluation models must be integrated. In accordance with the basic principles of controlling, the performance evaluation model must be able to evaluate the level of sustainability at different hierarchical levels of the organization, thereby revealing intervention points for decision-makers.

In the field of controlling, the normalization of the indicators can be achieved by applying the plan-fact analysis, thereby ensuring the comparison of the performance of the various KPIs, as well as the dynamic feedback [43]. Most controlling models are built along business criteria, primarily using validated financial-accounting and functional process data [44]. In order for the controlling system to be suitable for monitoring changes in sustainability aspects, it is necessary to use models that measure sustainability that take into account the company's objectives and the expectations of professional organizations. The sustainability fuzzy model must be structured according to measurement points, KPIs and professional aggregation levels in order to explore multi-level performance evaluation and intervention points. Under such conditions, the control system can directly process information about the efficiency of sustainability processes and identify intervention points to achieve the goals. For the evaluation of KPIs and the sustainability index as a peak indicator, several options are available when choosing a benchmark. Both external and internal benchmarks can be used during the evaluation process [45–47]. Among the external benchmarks, the best of the industry competitor, the expectations of professional organizations, and the results of the direct competitor or the comparison to the industry average can be equally relevant. In business, however, it is very difficult to obtain an external reference base and a sufficient amount of relevant data for performance evaluation, so a normative choice is needed, which also increases subjectivity and justifies the use of fuzzy logic. In business life, the most effectively available information can be internal benchmarks, such as the use of data from the past period, project data based on enterprise goals and strategy, or company-specific plan values determined by professional organizations.

From all of this that the use of various sustainability reports and sustainability indices, which typically focus on global and general data, cannot be considered sufficient for evaluating the actual sustainability performance of enterprises. Enterprises prepare these reports primarily for shareholders and state institutions and provide information about the company's level of sustainability through it. The primary purpose of the majority of reports and indexes is, therefore, not to evaluate real performance and provide detailed information but to influence the opinions of interested parties. As a result, the existing reports and indexes are not suitable for evaluating the level of sustainability based on general and organization-specific KPIs and for determining the areas to be developed based on the results [48].

The purpose of our research, in addition to the development of a model from a controlling point of view, is to illustrate the differences in sustainability value judgments based on standardized norms, thus proving the applicability and advantages of fuzzy logic in modeling for the evaluation of sustainability. We would like to emphasize the motivation of our research, which lies in providing enterprise managers with appropriate information in order to increase their level of sustainability and thereby incorporate the values expected by consumers, regulations, enterprise strategy and society into their operational processes. Therefore, the main goal of our model development is to create a controlling model that can be used synergistically with other controlling models and can be easily integrated into various enterprise resource systems (ERP).

Enterprise managers are often faced with difficult decision-making situations, as the interpretation of a specific sustainability indicator can be subjective, which makes it difficult to make appropriate decisions. Our model manages this subjectivity and helps managers to make effective decisions-making between the different expectations and threshold values of sustainability areas. By applying fuzzy logic, our model enables the integration of subjective information and decision-making support, so enterprise managers will be able to achieve sustainability objectives by taking into account the expectations of different areas. By applying our model, enterprises can describe the development related to the area of sustainability based on company-specific data and benchmarks. With this performance evaluation, company development can be tracked more precisely and comes with a value judgment closer to reality. As a result, the developed index, in contrast to several sustainability indices, enables the company to evaluate the change in the level of sustainability by integrating company-specific indicators in addition to global indicators. As a result, enterprises will be able to apply sustainable business practices, which will help increase the level of sustainability and meet different expectations.

This paper is organized as follows; Section 2 presents the data collection, the related methods and the steps of the developed model. Section 3 presents the results, during which we present the application of our model and the difference in evaluation based on the three expert groups. In Section 4 discussion, we describe the research found in the literature that is related to our research. Section 5 presents the conclusions based on the results. Section 6 presents the model's advantages, limitations and future research opportunities. Figure 1 illustrates the process of the research.

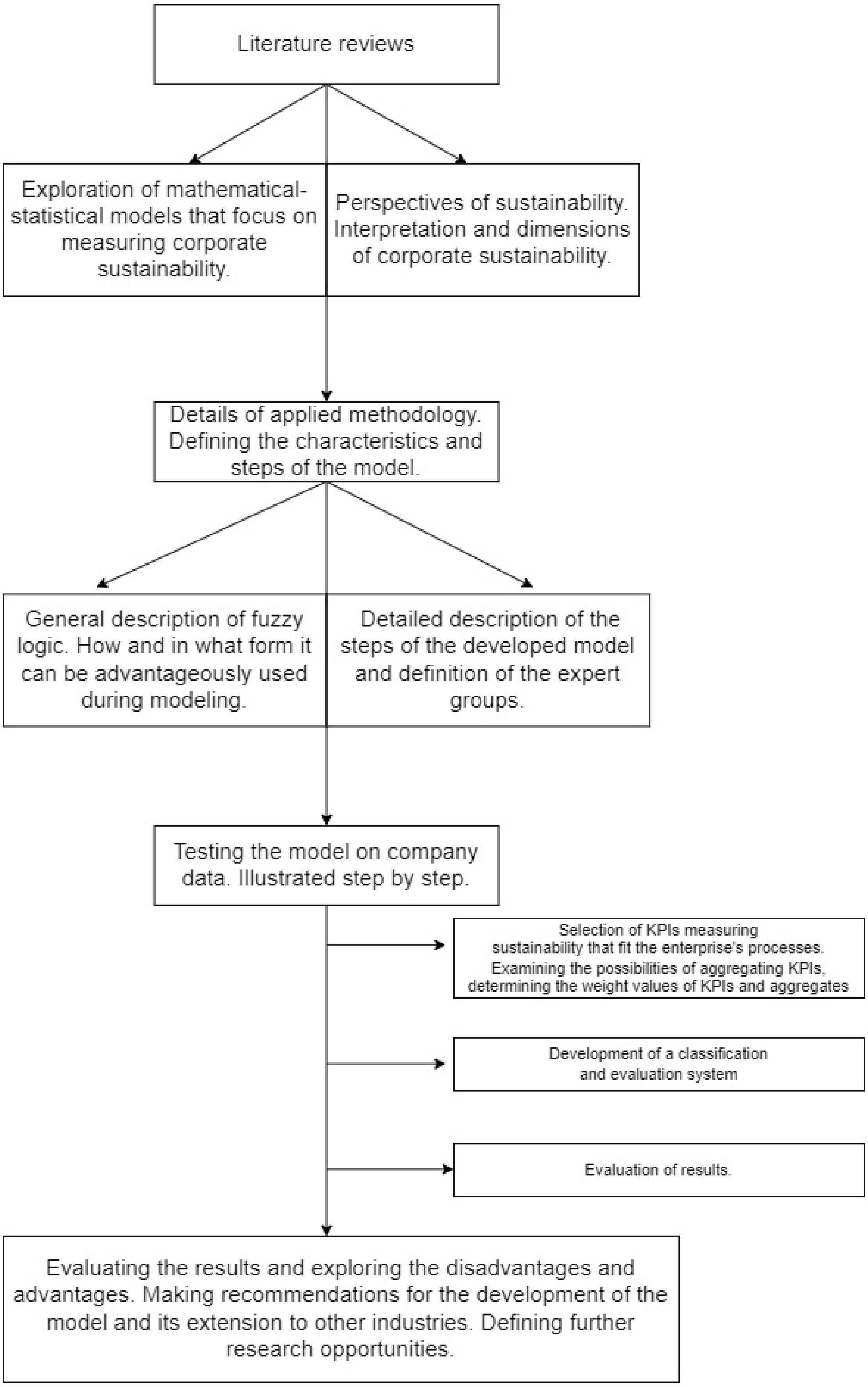

Figure 1. Flowchart of the research.

2. Materials and Methods

In our research, through an extended case study [49], we developed a performance evaluation model from a controlling point of view, which measures the level of sustainability based on various standardized norms and plan-fact analysis. The main activity of the organization included in the case study, Copy & Consulting Ltd. (Headquarters: Budapest, Hungary), is the production of packaging materials. The fact data related to company processes were provided by company databases and the ERP system. These data were used in model development and evaluations. To develop the model, sustainability KPIs had to be defined. In the model, we used KPIs that the company already uses in its controlling system. The method of data analysis during the research is illustrated in Figure 2.

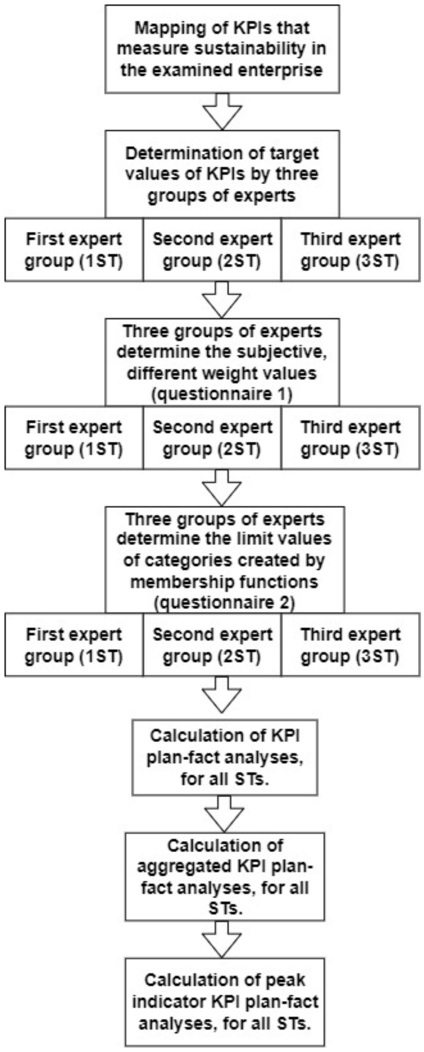

Figure 2. Methodological flowchart of the research.

The determination of the weight values, plan values and classification threshold values for the KPIs is subjective; in our case, it was determined based on the subjective opinion of the company managers and the experts of the professional organizations. The two professional organizations are the International Educations and Research Center Foundation (NOKKA) and the Institute of Rural Development and Sustainable Economy at the Hungarian University of Agricultural and Life Sciences (MATE). The opinions of managers and experts of professional organizations were surveyed using a questionnaire method. Since the indicators also contain subjective modifying factors, it is necessary to maintain the statement that it is conceivable that other actors would have associated a different value to each process. In order to avoid this and reduce the possibility of error to a minimum, we tried to examine the process from several aspects, negotiate objectively whenever possible and exclude any partiality. The possibility of error cannot be reduced to a minimum since this kind of measurement is not possible, so the inclusion of subjective opinions during the study is essential, which slightly reduces the validity. The professional organizations involved in the research studied the operation of the enterprise for 2 months (1 July 2022–30 September 2022), thereby creating a separate professional subjective opinion regarding the weight values, plan values and evaluation threshold of KPIs and aggregates. Experts from both professional organizations (NOKKA and MATE) participated in the research, whose field of expertise covers the field of sustainability. Experts teach and conduct research in this field. Each of the two questionnaires (Questionnaires S1 and S2) was filled out by 8-8 professionals from professional organizations. Enterprise managers from the company (Copy & Consulting Ltd.) participated in the research. The questionnaires (Questionnaires S1 and S2) were filled out by 8 middle and top managers who actively participate in the company's decision-making processes. Experts and company managers determined the weight values of the KPIs based on a fuzzy questionnaire (Questionnaire S1). The weight values of the three examined areas of sustainability (environmental, social and economy) were evaluated as aggregates in a manner similar to the KPIs, using a questionnaire method. The results of the questionnaires were placed in predefined classes, which were defined in advance. The reason for this is the management of subjectivity and vagueness in the field and in the answers by the questionnaire method. The weight values were therefore determined based on the results of the questionnaires. The results of the questionnaire survey were aggregated by means of an average calculation. Based on these, we determined three different weight values. The weight values of KPIs and aggregates were determined as follows: 0.80 (0–69%), 1.00 (70–89%) and 1.20 (90–100%). During the examination, we took into account that the same number of experts from both the enterprise and the professional organizations should participate in the questionnaire survey. The fulfillment of this condition enables the comparability of the available point values per KPI and per aggregate and the dispersion of the point values. Due to the distribution of the results of the questionnaire, it was not necessary to create additional weights. We applied the weights determined by the company managers and experts (NOKKA and MATE) as three separate analyses and did not aggregate them into one. The three standardized norms (STs) used in the research are the following: target values determined by company managers—classification threshold values (1ST), target values determined by NOKKA experts—classification threshold values (2ST), target values determined by MATE sustainability experts—classification threshold values (3ST). The target values for the different STs are the company's plan values, and in the case of professional organizations experts, the plan values are determined based on the on-site work spent at the company. As a result, the company and the professional organizations defined three different plan values. These plan values can be considered a uniform plan value per evaluator for all KPIs included in the analysis. In the model, target values are defined only for KPIs (lowest level). In this way, the result of each KPI can be interpreted as a ratio created on the basis of the plan-fact calculation. Based on the plan data, the plan-fact ratio associated with the sustainability indicators can be created. The calculation of the plan-fact ratio is also important from the point of view of normalizing the data, thereby making the indicators in different units suitable for use in the controlling model. Based on the result of the sustainability plan-fact ratio, the sustainability fact values can be evaluated in relation to the organizational plan values and the sustainability plan values created depending on the enterprise expectations and goals defined by professional organizations. The plan values belonging to the sustainability indicators cannot be considered as sharp values because their definition involves subjectivity and, therefore, may depend on several target values and subjective expert opinions, i.e., benchmarks. As a result, the evaluation of the level of sustainability is vague and depends on the benchmark. Target values are not determined at the additional levels since the aggregated values of the higher levels contain the target values related to the lower levels. In the research, we evaluated all KPIs at the hierarchical level and used average calculation as an aggregation method.

The formation of the classification threshold values for each KPI and aggregate was determined separately by the participants of company managers and the experts of professional organizations. The KPIs grouped for each sustainability area were determined based on literature reviews. The results of the KPIs and aggregates included in the analysis were evaluated along the STs. The peak indicator of our model is the sustainability index, which can be interpreted as the sustainability level of the company. The peak indicators were evaluated based on the various STs; therefore, at the top level, there are fuzzy numbers that represent the value judgments belonging to different standardized norms (Figure 3).

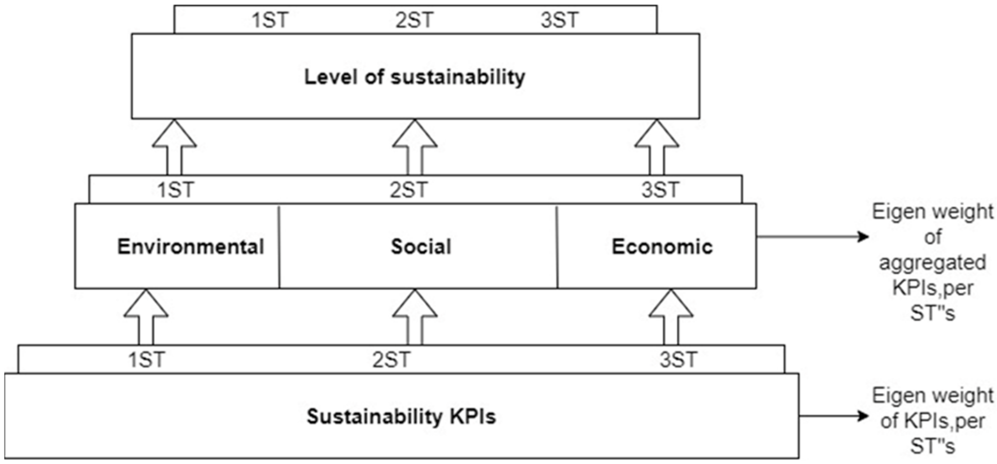

Figure 3. Controlling model to evaluate sustainability level.

The KPIs and aggregates, which depend on STs, are evaluated. So each KPI will have three subjective target values, which are the three STs. A fact value belonging to the KPI is separately compared to the STs. The plan-fact ratios are classified based on the threshold values of the given fuzzy triangle membership function. The classification thresholds were examined using a questionnaire method (Questionnaire S2). We aggregated the results of the questionnaire and determined the triangular membership functions of the various STs based on this. Based on the analysis of these membership functions, we determined the categories and classification thresholds for different STs. Our questionnaire (Questionnaire S2) predefined five categories. The questionnaires are to be completed on 10 October 2022–14 October 2022 happened between.

Before applying the fuzzy-logic methodology to evaluate the level of sustainability, the concept of fuzzy logic will be reviewed below. In the field of artificial intelligence research, researchers have been developing various expert systems since the 1950s, which created different conclusions based on data and knowledge bases and Boolean algebraic logic. Logical algebra is characterized by binary values: true–false. In the natural and social sciences, however, phenomena occur in many cases that cannot be properly defined. Modeling these phenomena with exact methods is inefficient and, in many cases, not even possible. As a solution to this problem, in 1965, Zadeh developed the fuzzy logic method of the continuum with an infinite set of values [50]. Fuzzy means vague; thus, in these systems, the membership in the given set is determined by the membership functions. The membership functions illustrate a set of values and an interval belonging to a given linguistic variable; for example, the evaluation of a given organization can be the value of a linguistic expression: unprofitable, moderately profitable and very profitable. Belonging to a given set can be defined using the function [51]. This operation is called fuzzification. A set of rules must then be developed that perform various operations and provide inferences using each linguistic expression.

In evaluating the level of enterprise sustainability, fuzzy-logic-based methods are common and, in most cases, refer to the vagueness of the value judgment [52,53]. The vague concept of sustainability comes from the fact that calculating the expectations and values of sustainability for a company, process or indicator is a very complex and unclear task. This lack of clarity creates an information-deficient environment where subjective opinions and estimates are decisive. In our research, we define the classification of sustainability KPIs and aggregated KPIs as fuzzy subsets. Applying the notation system of [50], the theoretical background of the method applied is as follows: a model based on fuzzy logic needs to define the universe (U), the elements (x_i) of "U", the elements (x_i) of "U", where U = {$x_1 + x_2 + \ldots\ x_m$}, and the fuzzy subset "A" is contained in "U", where

$$A = \left\{ \frac{x}{\mu_A(x) \mid x \in U} \right\}$$

The membership function of a fuzzy subset "A" is most often expressed by the following: μ_A: U → [0, 1], which assigns to each element x ∈ U the degree of membership of (x) μ(x) in A: $\mu_A(x) = \mu(x)$.

The most commonly used fuzzy logical operations are intersection, union and complement:

- Fuzzy sets: A fuzzy set is a generalization of a classical set, where each element has a degree of membership (often represented as a real number in the interval [0, 1]) in the set, rather than simply belonging or not belonging to it. Formally, a fuzzy set A in a universe of discourse X is characterized by a membership function μ_A: X → [0, 1], which maps each element x in X to its membership degree in A.
- Fuzzy subsets: subsets (A and B): Fuzzy subsets A and B are fuzzy sets defined in the same universe of discourse X. They have their respective membership functions, μ_A: X → [0, 1] and μ_B: X → [0, 1], which assigns membership degrees to the elements of X.
- Intersection of two fuzzy subsets, A and B: $\mu_{A \cap B} = \min\{\mu_A(x), \mu_B(x)\}$. The fuzzy intersection of two fuzzy subsets, A and B, denoted as A ∩ B is a fuzzy set with a membership function $\mu_{A \cap B}$: X → [0, 1], defined as $\mu_{A \cap B}(x) = \min\{\mu_A(x), \mu_B(x)\}$ for each element x in X. The fuzzy intersection represents the commonality between A and B, with the membership degree of an element x in A ∩ B being the minimum of its membership degrees in A and B.
- Union two fuzzy subsets A and B: $\mu_{A \cup B} = \max\{\mu_A(x), \mu_B(x)\}$. The fuzzy union of two fuzzy subsets, A and B, denoted as A ∪ B, is a fuzzy set with a membership function $\mu_{A \cup B}$: X → [0, 1], defined as $\mu_{A \cup B}(x) = \max\{\mu_A(x), \mu_B(x)\}$ for each element x in X. The fuzzy union represents the combination of A and B, with the membership degree of an element x in A ∪ B being the maximum of its membership degrees in A and B.
- The complement of A: $\mu_{A'}(x) = 1 - \mu_A(x)$ [50]. The fuzzy complement of a fuzzy subset A, denoted as $\overline{A}$ or A′, is a fuzzy set in the same universe of discourse X with a membership function $\mu_{\overline{A}}$: X → [0, 1] (or $\mu_{A'}$): X → [0, 1]), defined as $\mu_{\overline{A}}(x) = 1 - \mu_A(x)$ (or $\mu_{A'}(x) = 1 - \mu_A(x)$) for each element x in X. The fuzzy complement represents the "opposite" or "negation" of A, with the membership degree of an element x in $\overline{A}$ being the difference between 1 and its membership degree in A.

Our goal is to develop the control methodology of controlling–management, during which we develop a suitable model for monitoring areas that cannot be clearly measured. In the case of a controlling model, the primary criterion is the ability to integrate into ERP. The condition for integrability is a structured model with standard parameters, low required computing capacity for application, management of subjectivity and simple and flexible data collection–data processing. In our model, we used a questionnaire methodology to determine the threshold values of the fuzzy categories, which is the most frequently used data collection methodology in the case of management research. During the questionnaire survey of expert opinions, the most frequently used fuzzy functions are the triangle and the trapezoid function for the creation of fuzzy categories. The triangle and trapezoidal functions both represent fuzzy sets, but they have different forms and properties. The trigonometric function is often considered better in some cases because:

- Its structure and calculation are simpler: the triangle function consists of only three points (a, b, c), which form the vertices of the triangle. As a result, the calculation of function values is simpler and faster than in the case of the trapezoidal function, which consists of four points (a, b, c, d). In the case of the trapezoid function, the respondents should provide additional upper threshold values, which increases the complexity of the survey and the low required computing capacity for application.
- The calculation error is smaller: in the case of the triangular function, the calculation error is smaller since fewer parameters have to be taken into account during the calculations. In the case of the trapezoidal function, the probability of error is higher due to more parameters.
- Better intuition and interpretation: due to the simpler form of the trigonometric function, it is easier to interpret and more intuitive for experts. In the case of the trapezoidal function, the interpretation can be more complicated since the function has several sections and parameters.
- There is less chance of overfitting: the triangular function has fewer parameters, so there is less chance of the function adapting excessively to the training data, which may result in a decrease in the generalization ability of the model.
- It is easier to optimize the parameters: the triangular function contains fewer parameters, so the optimization of the parameters can be simpler and faster than in the case of the trapezoidal function. This can be especially beneficial when the parameters of the fuzzy system need to be set or optimized iteratively.
- Simpler form: the triangular fuzzy function has a simpler mathematical form, which makes implementation and calculations easier. So it can be faster and more efficient in terms of computing resources.
- Fewer parameters: the triangular fuzzy function has only three parameters (a, b, c), while the trapezoidal fuzzy function requires four parameters (a, b, c, d). Fewer parameters reduce model complexity and enable faster learning or optimization.
- Better discrimination: the triangular fuzzy function enables clearer discrimination between different fuzzy sets since it has only one vertex. The trapezoidal fuzzy function has two "flat" parts, which can make it more difficult to distinguish.
- Less information: if there is less information about the problem or the data are more uncertain, then the use of the triangular fuzzy function can be reasonable since it requires fewer parameters for estimation.

In addition to the applicability advantages of the listed triangular function, its use by us is justified by the questionnaire data collection and the development criteria of the controlling model. In the case of the questionnaire used in our research, the experts determined the minimum percentage for the 5 evaluation categories. In this way, the threshold values of the fuzzy intervals were determined for each expert, and threshold values were collected using the 2nd questionnaire. From the results of the questionnaire, the answers belonging to the categories were averaged so that a function picture aggregated based on the answers could be created. This also illustrates the advantages of the fuzzy triangle function, i.e., the low level of complexity of the model, as well as the simplicity of the data collection and calculation process and the dynamic nature of the model. This can greatly facilitate the integration of the controlling model into ERP systems. However, it is important to note that the triangular function is not always better than the trapezoidal function. The advantages of the trapezoidal function include greater flexibility and the ability to more accurately model uncertain behavior or processes in the real world. Choosing the right function depends on the type of problem to be solved and the requirements to be met. Regarding the analysis of the triangle and trapezoid fuzzy function, we found the triangle function suitable for our research.

Steps of modeling:

1. Selection of KPIs measuring sustainability that fit the enterprise's processes. Examining the possibilities of aggregating KPIs and determining the weight values of KPIs and aggregates.
2. Development of a classification and evaluation system
    - 2.1. Evaluation and quantification of the plan values of KPIs determined by subjective expert opinions.
    - 2.2. Development of plan-fact ratios based on standardized norms. Formation of the classification threshold values using a fuzzy triangular membership function.
3. Evaluation of results.
    - 3.1. Evaluation of KPIs based on standardized norms.
    - 3.2. Development and evaluation of aggregates and sustainability indexes as peak indicators based on various standardized norms. (Each standardized norm has a peak indicator)
4. Evaluation of results and exploration of intervention points.

3. Results

The performance evaluation model we built evaluates the sustainability level of the organization included in the analysis. Determining the sustainability level of the examined organization is a complex task due to the diversity of sustainability definitions and the lack of a generally applicable measurement method and indicator system.

3.1. Selection of KPIs Measuring Sustainability That Fit the Enterprise's Processes: Examining the Possibilities of Aggregating KPIs, Determining the Weight Values of KPIs and Aggregates

KPIs affecting sustainability form the basis of the controlling system we have built. During the selection of KPIs, it was a primary consideration that KPIs already used in the ERP system of the examined enterprise should be included in the model. It is important to emphasize that these KPIs are subjective, depending on the profile of the enterprise under examination in each case. During the selection of KPIs, KPIs monitoring sustainability aspects were collected. This was followed by the weighting of the KPIs from a sustainability point of view, which was evaluated on the basis of expert opinions based on the 1st questionnaire. Figure 4 illustrates the selected KPIs and their calculation method. We grouped the KPIs according to the three areas of sustainability (environmental, social and economy).

After collecting the KPIs, the aggregated KPIs are created. In our study, the first aggregation takes place according to three areas of sustainability. After that, the second aggregation is the creation of a sustainability index, which is created by aggregating the three sustainability areas. With the peak indicator, we evaluate the sustainability level of the organization in an aggregate indicator. KPIs and each aggregate have a separate weight value. We determined the weight value of KPIs and aggregates based on the opinions of the three expert groups (Questionnaire S1). In our research, we defined three weight value categories: 0.8, 1 and 1.2. The higher the weight value of a KPI, the more influence it has on the level of sustainability of the company. In our survey, each expert group includes 8 people, so the maximum possible score as a KPI is 40 points. The percentage value of the average calculation is assigned to the predefined weight value category, and thus, the KPI receives the weight value. The weight values express the relative prioritization of KPIs at the same level and aggregates at the same level. Furthermore, the weight values make it possible to use the weighted average calculation as an aggregation method.

Category	KPI No.	KPI name	Calculation methods
Environmental	1.	Renewable energy rate	Renewable energy / Total energy used
	2.	Efficiency of energy use rate	Energy used (kWh) / Thousend product units (1000 units)
	3.	Waste reduction rate	Energy used (kWh) / Thousend product units (1000 units)
	4.	Reusable or recycled material rate	Energy used (kWh) / Thousend product units (1000 units)
	5.	Paper reduction	Total digitized document, information unit (pieces) / Total document, information unit (pieces)
	6.	Carbon footprint	Total digitized document, information unit (pieces) / Total document, information unit (pieces)
	7.	Efficiency of water use rate	Water used (m3) / Thousend product units (1000 units)
	8.	Fossil energy consumption	GJ / Thousend product units (1000 units)
	9.	Fuel consumption in transportation	Used petrol/diesel (l) / Hundred product units (100 units)
	10.	Land consumption for transport	Km^2 / Thousend product units (1000 units)
	11.	Railways use rate	Transport by train (Km2) / All transportation methods (Km2)
	12.	Noise emission level	Number of limit value exceedances / Total number of measurements
	13.	Use of packaging material	Packaging material (tons) / Thousend product units (1000 units)
	14.	Use of renewable packaging material	Renewable packaging material (tons) / Total packaging material (tons)
	15.	Stand-by time to operating time	Stand-by time (hours) / Operating time (hours)
Social	16.	Work shift	Number of hours worked per week / Normal work shift (8 hours)x Number of employees per week
	17.	Overtime	Total overtime per week (hours) / Number of employees per week
	18.	Labor turnover	Number of exits workers in a year / Average number of workers in a year
	19.	Salary	Annual salary cost / Number of employees
	20.	Employment gender ratio	Number of female workers / Number of total workers
	21.	Learning willingness of employees	Average number of employees participating in training in a year / Average number of employees in a year
	22.	Work injury (injury that heals within 8 days)	Number of days in which work injuries occurred / Total number of working days
	23.	Customer complaints	Number of complaints received from the customers / Total number of customers served

Figure 4. KPIs measuring sustainability.

3.2. Development of a Classification and Evaluation System

The plan values of the KPIs we use were determined based on subjective expert opinions. The plan values of the KPIs were determined separately for the three STs. In the case of 1ST, the enterprise's managers determined the plan values of the KPIs, while in the case of 2ST and 3ST, the experts of the professional organizations determined the company-specific plan values for the various KPIs. The plan values set by the professional organizations were determined specifically for the enterprise based on the on-site work. As a result, a quantified plan value for each KPI was created for each ST. During the determination of the KPI plan values, the experts took into account the companies' unique characteristics, market situation and competitors' performance. The goal of defining plan values was to set targets that are realistic yet challenging for companies, thus encouraging them to continuously improve and increase efficiency. After defining the plan values, three different plan-fact ratios were created for each KPI. The plan-fact ratio numbers are located on the evaluation scale, the classification threshold values of which were formed by the fuzzy triangle membership function. The triangular membership functions were determined by evaluating the value judgments of the three professional organizations. During the survey, we used a questionnaire method (Questionnaire S2), in which the threshold values for the predetermined classification category were evaluated based on the experts' opinions. Functions act as a calculation methodology with which KPIs, aggregates and peak indexes are evaluated and classified. With the questionnaire survey, we determined interval peaks based on subjective expert opinions, which can be interpreted as local peaks of individual experts within the given category. The peak point means the point equidistant between the threshold of the two categories. The individual subjective individual values obtained in this way were averaged to create the common fuzzy function, thereby trying to reduce the possibility of error arising from subjectivity. (We also checked that if we receive subjective opinions that are very different from the sample, it is necessary to correct them. However, we did not receive any questionnaire answers that did not fit the sample or were completely different from the answers, so we did not have to deal with this exclusion of the possibility of error.) So if the KPI plan-fact analysis percentage value is slightly below the peak point of the given category, it starts to blur into the category below it, but it still belongs to the same category; the same rule applies for higher values.

The classification is based on linguistics terms, the five linguistic terms were predefined in our research in order to perform the analysis effectively, but the threshold values of the linguistic terms classes were determined based on the opinions of the professional organizations (Questionnaire S2). When applying the linguistics terms of the classes, it is not the value recorded on the scale but the threshold values and standardized norms that are decisive. The application of these fuzzy triangle membership function-based categories enables the evaluation and classification of KPIs based on linguistic terms, making the performance more easily understandable and interpretable for decision-makers.

3.3. Evaluation of Results

KPIs and aggregates are classified according to the three STs, which points out that the values of the plan-fact ratios of KPIs and aggregates and the classification threshold are different, and the same fact value can be placed in a different evaluation class depending on the context determined by the professional organizations (Table 1).

The function used for classification:

$$\sigma_{\mathrm{j}} = \frac{\sum \frac{A_{ji}}{N_j} \times \xi_i}{K}$$

where the following definitions apply: A: the fact value of the KPI, N: the predefined plan value for the KPI, K: the examined element number belonging to the KPI/aggregate, ξ_i: the derived value of weight. In other words, with the function, we examine how important and critical the distance of certain KPI values from the norm is. By definition, a larger deviation with a small weight is not necessarily a problem, while in the case of a critical, i.e., very highly weighted KPI, a smaller deviation can be critical. For example, if, according to the company's assessment (1ST), KPI2 (efficiency of energy use rate) affects the sustainability level of the company with a higher priority, it is calculated with a higher weight value compared to KPI5 (paper reduction). So if the value of the KPI5 (paper reduction) improves, it does not have as much impact on the value of the Environmental aggregated KPI and thus on the company's level of sustainability as a peak indicator, as does the KPI2 (efficiency of energy use rate). The processes are not all involved with the same weight, so it is necessary to correct the deviation from the norm with importance.

Table 1. Data table of KPIs for sustainability areas.

Sustainability Dimensions	KPI No.	1ST			2ST			3ST		
		Weight	Value	Cat.	Weight	Value	Cat.	Weight	Value	Cat.
Environmental	1	1.20	−12.00%	C.	1.00	5.15%	E.	1.20	−14.95%	C.
	2	1.20	−5.78%	A.	1.20	2.00%	G.	1.20	−9.35%	C.
	3	1.00	0.50%	E.	1.00	0.50%	A.	1.00	−3.50%	N.A.
	4	1.20	−7.43%	N.A.	1.00	1.05%	G.	1.00	−16.55%	C.
	5	1.00	8.53%	E.	0.80	12.55%	E.	1.00	2.50%	A.
	6	0.80	−1.32%	G.	1.00	5.15%	E.	1.20	−8.15%	C.
	7	1.00	2.42%	E.	0.80	2.42%	G.	1.00	−9.30%	C.
	8	1.00	−8.08%	N.A.	0.80	2.50%	G.	0.80	−16.14%	C.
	9	1.20	4.95%	E.	1.00	−0.50%	A.	1.00	−9.66%	C.
	10	0.80	0.05%	E.	0.80	0.05%	A.	0.80	1.10%	A.
	11	0.80	0.50%	E.	1.00	0.80%	A.	0.80	−4.88%	N.A.
	12	0.80	−1.29%	G.	1.00	−1.80%	A.	0.80	−6.72%	N.A.
	13	1.00	6.85%	E.	1.20	15.95%	E.	1.00	0.75%	A.
	14	1.00	2.22%	E.	1.20	3.50%	G.	1.20	−8.02%	C.
	15	1.00	−2.29%	G.	0.80	−1.20%	A.	0.80	5.72%	G.
Social	16	1.00	−5.26%	A.	1.00	−6.30%	C.	0.80	1.56%	A.
	17	1.00	−4.75%	A.	1.20	−3.25%	N.A.	0.80	−10.80%	C.
	18	1.20	0.81%	E.	0.80	−2.30%	N.A.	0.80	−3.57%	N.A.
	19	0.80	4.00%	E.	1.00	2.80%	G.	1.00	0.80%	A.
	20	0.80	9.10%	E.	0.80	−0.50%	A.	1.00	8.75%	E.
	21	0.80	−8.90%	N.A.	1.00	0.50%	A.	1.20	−6.50%	N.A.
	22	1.20	0.20%	E.	1.20	0.00%	A.	1.00	0.00%	A.
	23	1.20	−1.17%	G.	0.80	1.95%	G.	1.00	2.40%	A.
	24	1.20	4.50%	E.	0.80	2.60%	G.	1.00	6.40%	G.
	25	1.00	0.00%	G.	1.00	0.00%	A.	1.20	−5.50%	N.A.
	26	1.00	−13.20%	C.	1.20	0.50%	A.	1.20	−18.25%	C.
Economic	27	0.80	−2.48%	G.	1.00	6.14%	E.	1.00	−1.72%	A.
	28	1.00	0.00%	G.	0.80	0.50%	A.	0.80	1.50%	A.
	29	0.80	−2.95%	G.	0.80	4.10%	E.	1.00	0.00%	A.
	30	1.20	5.09%	E.	1.00	12.67%	E.	1.20	4.52%	A.
	31	1.00	0.80%	E.	0.80	9.74%	E.	1.20	5.24%	G.
	32	0.80	−8.33%	N.A.	1.20	−1.42%	A.	1.00	−4.64%	N.A.
	33	0.80	−0.95%	G.	1.20	0.20%	A.	1.20	1.80%	A.
	34	1.00	−0.55%	G.	1.00	2.50%	G.	1.00	1.25%	A.
	35	1.00	1.50%	E.	0.80	4.20%	E.	0.80	8.30%	E.
	36	1.20	2.50%	E.	1.00	3.20%	G.	1.20	1.60%	A.

Categories (Cat.):
C. = Critical
N.A. = Not Acceptable
A. = Acceptable
G. = Good
E. = Excellent

Calculating fuzzy triangle membership functions from the expert questionnaire:

1. The first step is collecting the experts' responses from the questionnaire. This includes the determination of plan-fact ratios for KPIs s of classification threshold values (Questionnaire S2).
2. The degree of belonging to each class is determined based on the experts' opinions. For example, if 80% of the respondents believe that a given aggregated "X" value belongs to a specific category, the degree of belonging to that category will be 0.8, while the

degree of non-belonging will be 0.2. This method reflects the experts' opinions and makes the decision-making process reliable.

3. Determining the triangle membership functions based on the values given by experts, which include the minimum, maximum and central values. Subsequently, the triangle membership functions are calculated using formulas that mathematically describe them.
4. Using the triangle membership functions, we calculate the classification of KPIs and aggregates based on the company's sustainability level. During the calculation, the difference between the fact value (A) and the plan value (N) is determined, as well as the classification of individual elements with the help of weighted values (ξ_i).

We defined five different categories to determine the sustainability level of the organization. The five classification categories and fuzzy triangle membership functions are different for STs (Figures 5–7). On the function graphs, the vertical axis shows the dispersion of the experts' answers.

$$T_j \begin{cases} \text{Critical} & \text{if } \sigma_j < 0.90 \\ \text{Not acceptable} & \text{if } \sigma_j \in [0.90; 0.93) \\ \text{Acceptable} & \text{if } \sigma_j \in (0.93; 0.97) \\ \text{Good} & \text{if } \sigma_j \in (0.7; 1.0] \\ \text{Excellent} & \text{if } \sigma_j > 1.0 \end{cases}$$

$$T_j \begin{cases} \text{Critical} & \text{if } \sigma_j < 0.96 \\ \text{Not acceptable} & \text{if } \sigma_j \in [0.96; 0.98) \\ \text{Acceptable} & \text{if } \sigma_j \in (0.98; 1.01) \\ \text{Good} & \text{if } \sigma_j \in (1.01; 1.04] \\ \text{Excellent} & \text{if } \sigma_j > 1.04 \end{cases}$$

$$T_j \begin{cases} \text{Critical} & \text{if } \sigma_j < 0.92 \\ \text{Not acceptable} & \text{if } \sigma_j \in [0.92; 0.98) \\ \text{Acceptable} & \text{if } \sigma_j \in (0.98; 1.05) \\ \text{Good} & \text{if } \sigma_j \in (1.05; 1.08] \\ \text{Excellent} & \text{if } \sigma_j > 1.08 \end{cases}$$

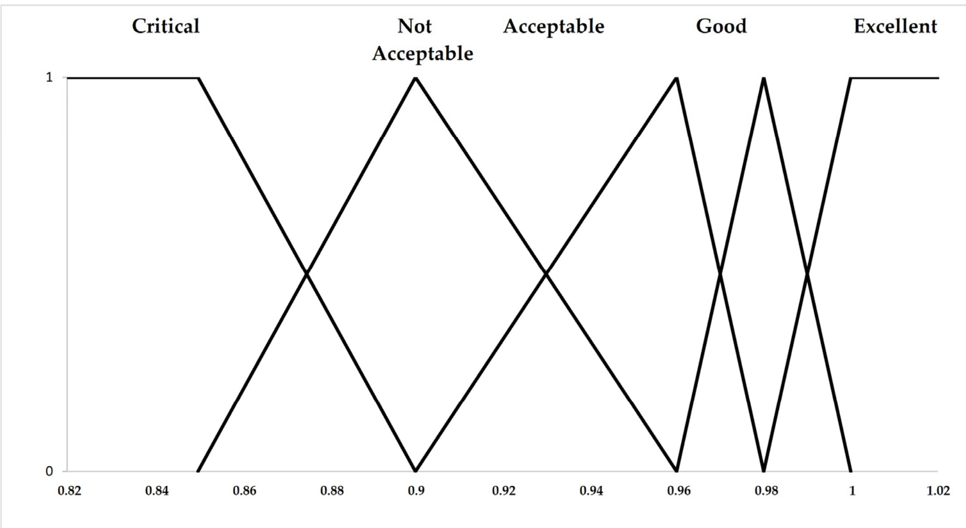

Figure 5. Fuzzy function (Enterprise managers).

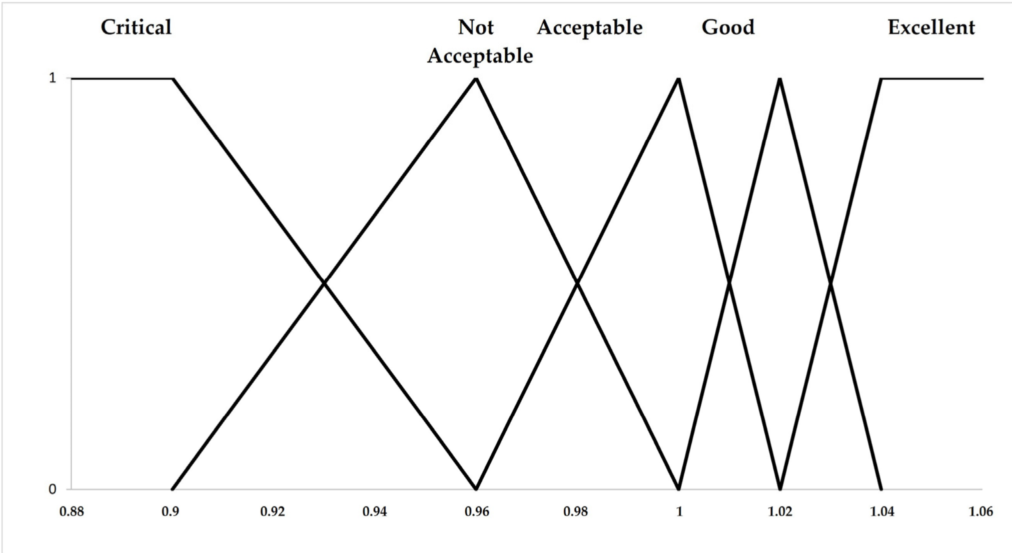

Figure 6. Fuzzy function (NOKKA experts).

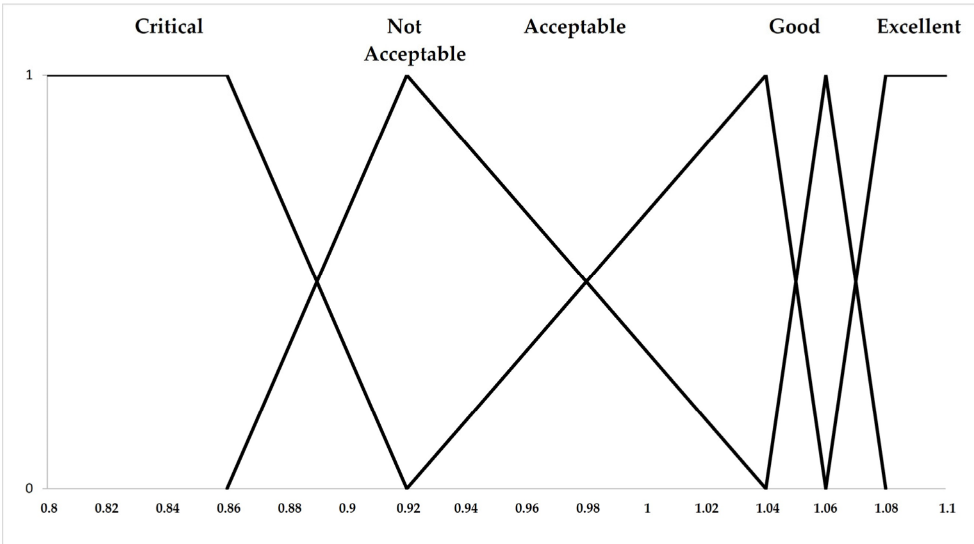

Figure 7. Fuzzy function (MATE experts).

By applying the fuzzy function, the sustainability level of the enterprise can be evaluated using the five classification categories and various STs. The functions serve as a feedback function for the enterprise indicating the level of sustainability.

Table 1 shows the subjectivity resulting from the difference in opinion of different expert groups. This subjectivity results primarily from the vague formulation of sustainability goals and expectations. Table 1 shows that for a given KPI, the plan-fact analysis ratio is different. This discrepancy results from the difference in the definition of the plan value of the three expert groups. The evaluation of the plan-fact ratios along different classification threshold values also results in differences in the evaluation of the fulfillment of sustainability aspects.

In order to reduce subjectivity and the calculation method, we use the results of KPI2 as an example. It can be seen that the value judgments of different expert groups regarding KPI2 are different. Therefore, the fact value of KPI2 is different in percentages compared to the different plan values determined by the expert groups. These different plan-fact analysis ratios are −5.78% in the case of 1ST, 2.00% in the case of 2ST, and −9.35% in the case of 3ST. These results are evaluated based on membership functions for different STs.

- In the case of 1ST, the −5.78% plan-fact deviation equals 94.22% performance, which is categorized as Acceptable based on the threshold values in Figure 5.
- In the case of 2ST, the 2.00% plan-fact deviation equals 102.00% performance, which is categorized as Good based on the threshold values in Figure 6.
- In the case of 3ST, the −9.35% plan-fact deviation is equal to 90.65% performance, which is categorized as Critical based on the threshold values in Figure 7.

Overall, based on the results (Table 1), it can be stated that 1ST and 2ST evaluate the results of the company's sustainability KPI ratios more positively than 3ST.

Mathematically, the information content of weighted KPIs is higher at the aggregate level since weighting takes into account the importance and relevance of KPIs in terms of achieving sustainability goals. If the KPIs are not weighted, the aggregated KPI is simply the average of 'N' KPIs. However, this method does not take into account the difference in importance or relevance between KPIs. However, in the case of weighted KPIs, we assign a weight to each KPI, which reflects the importance of the KPI based on sustainability considerations. In this case, the aggregated KPI results from the average of the weighted KPIs. A weighted aggregate KPI has a higher information content as it takes into account the importance and relevance of the KPIs. The weighted method allows companies to prioritize the most important KPIs and thereby gain a more accurate picture of their sustainability performance. In the (weighted) formula of the aggregated KPI, the weights influence the contribution of each KPI to the total value so that the final result better reflects the companies' sustainability priorities and the achievement of their goals.

The weighted average of the KPI ratios included in the analysis represents the value of the aggregated KPIs. Aggregation takes place along three areas of sustainability (Table 2). During the analysis of the aggregate values, it can be stated that the STs resulted in completely different classification categories for the evaluation of the aggregates. For example, in the case of the aggregated KPI of the environment, based on the data in Table 2, it can be seen that the value judgments of the different expert groups led to classification in different evaluation categories. So the aggregated KPI value of the environment is the weighted average of the values of the plan-fact analysis of the KPIs belonging to the area of the environment (KPI1–KPI15). This is an aggregated value that shows the environmental sustainability level of the organization being examined. The aggregate KPI of the environment is −1.05% in the case of 1ST, 0.61% in the case of 2ST, and −8.07% in the case of 3ST. These results are evaluated based on membership functions for different STs.

- In the case of 1ST, the average deviation of −1.05% is equal to 98.95% performance, which is categorized as Good based on the threshold values in Figure 5.
- In the case of 2ST, the 0.61% average deviation equals 99.39% performance, which is classified as Acceptable based on the threshold values in Figure 6.
- In the case of 3ST, the −8.07% average deviation is equal to 91.93% performance, which is categorized as Critical based on the threshold values in Figure 7.

Table 2. Data table of sustainability areas.

Sustainability Dimensions	1ST			2ST			3ST		
	Weight	Value	Cat.	Weight	Value	Cat.	Weight	Value	Cat.
Environmental	1.00	−1.05%	G.	1.20	0.61%	A.	1.20	−8.07%	C.
Social	1.00	0.49%	E.	1.20	−2.26%	N.A.	1.20	−2.56%	N.A.
Economic	1.20	−4.09%	A.	0.80	−0.21%	A.	1.00	5.85%	G.

Categories (Cat.):

C. = Critical
N.A. = Not Acceptable
A. = Acceptable
G. = Good
E. = Excellent

The determination of different weight values of the KPIs per ST (Table 1) greatly influenced the differences in the evaluation of the aggregates.

The weighted average of the aggregates represents the value of the peak indicator (Table 3). The aggregates were evaluated by the three expert groups with different weight values (Table 2). It expresses the prioritization of the weight values between sustainability areas, per expert groups. Aggregation is performed using a weighted average calculation, during which the three areas of sustainability are aggregated separately as STs. Thus, in our analysis, the three STs result in three different peak indicators.

Table 3. Data table of sustainability index per STs.

	1ST		2ST		3ST	
	Value	**Cat.**	**Value**	**Cat.**	**Value**	**Cat.**
Level of Sustainability	−1.82%	G.	−0.72%	A.	−2.30%	N.A.

Categories (Cat.):

C. = Critical
N.A. = Not Acceptable
A. = Acceptable
G. = Good
E. = Excellent

In Table 3, the sustainability level of the company in the case of 1ST is −1.82%, in the case of 2ST, −0.72% and in the case of 3ST, −2.30%. These results are evaluated based on membership functions for different STs.

- In the case of 1ST, the average deviation of −1.82% is equal to 98.18% performance, which is categorized as Good based on the threshold values in Figure 5.
- In the case of 2ST, the −0.72% average deviation is equal to 99.28% performance, which is categorized as Acceptable based on the threshold values in Figure 6.
- In the case of 3ST, the −2.30% average deviation is equal to 97.70% performance, which is classified as Not Acceptable based on the threshold values in Figure 7.

It can be seen from the results of the three peak indicators that the evaluation of sustainability is subjective, and our analysis proves that sustainability as a concept cannot be clearly defined. The different value judgments of the three expert groups are also relevant separately since the truth content of the STs in relation to each other can be considered to be equal in the analysis.

The evaluation of the effectiveness of the enterprise according to sustainability aspects varies according to the examined standardized norms. The results obtained according to different standards express the company's level of sustainability with the same approach to reality. Fuzzy logic, therefore, in this model does not serve and is not intended to create a classification with accurate reality content. Its purpose is to illustrate that the assessment of the sustainability level of the enterprise depends on the context.

3.4. Evaluation of Results and Exploration of Intervention Points

When comparing the results of the analyzes of different standardized norms, intervention points can be revealed. These intervention points support the planning of goals for the future and the analysis of the effects of extreme circumstances affecting the operation of the business. In the case of the enterprise examined in the analysis, there are several critical points. Of these, KPI1 (Renewable energy rate) and KPI26 (Sustanibility suppliers) should be highlighted, which were also critically evaluated based on two STs. A review of these KPIs is recommended since, in addition to the critical classification category, there is also a significant difference in the deviation between the classification categories per ST. This discrepancy may be due to the high subjectivity of defining the plan value. Therefore, it is necessary to increase the knowledge and information content necessary to define the plan value since, in such cases, by reducing subjectivity, a more realistic evaluation can be achieved.

4. Discussion

In recent years, numerous measurement methods and frameworks have been proposed to determine the level of enterprise sustainability [54,55]. It can be formulated that the methods and frameworks used to measure sustainability have numerous shortcomings, primarily due to the lack of consensus in defining and standardizing sustainability. The lack of consensus is particularly evident in the determination of sustainability indicators. In many cases, it is difficult to identify those indicators that truly influence an organization's sustainability level and are characteristic of a particular company or industry [56]. Engida et al. (2018), in their study, identified and grouped KPIs for measuring sustainability performance according to ESG (environmental, social, governance) criteria [57]. Aras (2018) defined sustainability indicators in five areas (environmental, social, governance, finance and economic) [58]. In our study, we followed Hui et al. (2019) approach and selected the indicators based on economic, environmental and social areas [59]. The grouping of sustainability indicators is crucial for more efficient measurement and analysis of overall enterprise sustainability performance [60–63] pointed out that using aggregated measurement indicators leads to greater accuracy and complexity and improves sustainability performance evaluation. In their study, in order to evaluate the level of enterprise sustainability, sustainability KPIs were aggregated according to the three sustainability areas (economic, environmental and social). The three sustainability areas were also aggregated to express the sustainability level in a peak indicator. The created peak index can be used to evaluate the sustainability level of the company. Searcy (2016) also formulates the effectiveness of aggregation in the joint evaluation of different sustainability dimensions [64]. However, due to the complexity of sustainability performance measurement, aggregation methods are not always able to reflect reality.

To assess enterprises' sustainability in a way that approximates reality, we applied fuzzy logic, which is suitable for evaluating areas with high subjectivity. Numerous studies have highlighted the advantages of applying fuzzy logic in sustainability evaluation [65,66]. Bhyan et al. (2023) point out that the importance of evaluation criteria is determined by various factors, such as whether it has long-term effects on the enterprise and projects or the extent to which the criterion is related to the company's goals and strategy [67]. The importance and relevance of criteria are determined based on the various expectations of decision-makers. Pavláková Dočekalová et al. (2017) [66] KPI weights are determined based on the subjective preferences of an expert group [66]. In our study, the importance of sustainability KPIs and areas was determined based on subjective expert opinions, consistent with the study by Pavláková Dočekalová et al. (2017) [66].

The advantage of the Mamdani-type dependency model in the analysis of incoherence is that it can detect and handle contradictions between expert opinions. Mamdani-type algorithms are usually used in conjunction with the AHP (analytic hierarchy process) method, which determines the ratio of incoherence between opinions. The advantage of the Mamdani model is that if the experts' opinions contradict each other, the model can deal with this contradiction and find the best compromise [68]. Therefore, according to Mohammed et al. (2021), the advantages of Mamdani functions in terms of handling incoherence are obvious [68], but according to Sadollah (2018), triangle and trapezoidal functions may be more advantageous due to the simplicity, flexibility and robustness of their application to modeling expert opinions [69]. Since expert opinions are often uncertain and characterized by variability, these functions can effectively and authentically handle opinions and better reflect reality. The application of the fuzzy triangular membership function in evaluating the sustainability level of enterprises is not common. Pislaru et al. (2019) applied the fuzzy triangular function to evaluate the sustainability level of enterprises [70]. The KPIs and aggregated areas are the same as those used in our study (environmental, social and economic). However, the KPIs included in the analysis are completely different. In the evaluation process, the fuzzy triangular function was used to evaluate every subjective element. Similar to Pislaru et al. (2019) study [70], in our research, we employed the fuzzy triangular membership function to handle uncertainty arising from sustainability measurement and consider and evaluate ambiguous criteria-relationships. Kouikoglou-Phillis (2010), in their study [60], the fuzzy logic-based evaluations are consistent with the sustainability level evaluation model we have developed. Our model, based on fuzzy logic, does not define exact values but provides the evaluation classes of KPIs and aggregates as fuzzy numbers. In terms of formalizing inferential processes, the model provides only approximate answers during the analyses [71]. The fuzzy methodology is widely used in sustainability-level performance evaluation. Its most common occurrence in the literature is seen in the evaluation of supply chains, suppliers and enterprise performance evaluations [72–75].

5. Conclusions

In our research, we developed a controlling model using fuzzy logic through an extended case study, which allows enterprises to effectively measure their level of sustainability and identify their intervention points. Our case study focused on an enterprise that produces premium product packaging. Using data from the year 2022 of the studied company, we demonstrated the functioning of our controlling model. We used KPIs already employed by the business, as well as aggregated KPIs based on areas that influence sustainability as formulated in the literature. Based on these, we established a hierarchical model that enabled the enterprise's level of sustainability to be evaluated according to different standardized norms.

Unlike performance evaluation models, this controlling model is not based on benchmark analysis, professional opinions, or enterprise strategic analysis. The developed model considers the ambiguity arising from measurability, goal-setting and various subjective expert opinions. The model handles the subjectivity arising from measurability and goal-setting by applying different standardized norms. This enables an analysis that can take into account different relationships in relation to organizational goals, expectations and professional expert opinions. In the case of enterprise and professional expert opinions, both the plan values and classification thresholds are determined differently.

Our results show that assessing an organization's level of sustainability is not straightforward. Our research has revealed, within the framework of a case study, that the level of sustainability can vary depending on the given context. By applying different subjective expert opinions and plan values, we illustrate that the subjectivity present in the area is significant, but this high subjectivity can be effectively managed by applying fuzzy logic. The research clearly showed that the norms defined by professional expert groups are much more restrictive and impose higher expectations on sustainability evaluation than those defined by enterprise managers. As a result of this difference, evaluation along the two standardized norms (2ST and 3ST) resulted in sharply distinct classification categories for most KPI evaluations. Enterprise managers placed the company's sustainability level in the "Good" category, while according to the expert groups, the evaluated company's sustainability level into the "Acceptable" category in the 2ST case and into the "Not Acceptable" category in the 3ST case.

The goal of model development is to create a controlling model that fits effectively into the company's controlling and ERP systems. The complexity of our model and its calculation requirements are low due to the use of the triangular membership function. The implementability of our model in business practice is supported by the structure with predesigned standard parameters. By applying the model, organizations have the opportunity to perform a controlling assessment in an area with a high degree of subjectivity. With our model, we form a kind of bridge between the theoretical performance evaluation and the business expectations.

Further research is needed to explore which standardized norm based on sustainability standards would be more relevant for evaluating the sustainability level of the enterprise. The expert groups developed the plan values primarily based on global macro data, industry-specific experience, and specific enterprise characteristics, while the enterprise managers developed the plan values primarily based on strategic directions, knowledge, experience and enterprise capacity. As a result of the study, the performance classification capability of the model could be further refined if the three groups could reach a common opinion, thereby creating reference values that are closer to reality.

6. Implications of the Study

Our study can serve as a general model in the field of enterprise sustainability-level performance evaluation. The constructed model enables the evaluation of the sustainability level of companies along several standardized norms. With our model, the intervention points at different hierarchical levels can be revealed, thereby supporting managerial decision-making. The classification of sustainability KPIs and aggregates based on different standardized norms results in different value judgments. This difference in value judgment is perfectly illustrated by the results of our study. In this way, it can be stated that the evaluation of the level of enterprise sustainability is subjective and may vary depending on the examined context. Due to the subjectivity of the evaluation of the level of sustainability, we use fuzzy logic in our model, which manages the subjectivity in the system, but at the same time, does not strive to achieve objectivity. We evaluate the level of sustainability of our model not with an exact value but by specifying intervals. However, the fuzzy values provided by the triangular functions we use can be appropriate in the evaluation of enterprise sustainability, as it provides appropriate guidelines for the development of processes and systems necessary to increase sustainability.

The advantage of the model is that the triangular membership functions are suitable for determining the threshold values derived from the subjective opinion of expert groups (standardized norms), thereby handling non-exact objectives. The model is able to express the level of sustainability of the examined enterprise in aggregated peak indicators. The hierarchical levels and aggregation options of our model can be expanded indefinitely depending on the computing capacity. The model is suitable for evaluating enterprise sustainability performance at all strategic, operational and functional levels in an aggregated manner. The model supports strategic and operational decisions quantitatively, as the ratios created by the plan-fact analysis can be applied in a normalized form at all hierarchical levels.

The applied plan-fact analysis provides an opportunity to standardize the model. The different standardized norms have different plan values, which become comparable with each other during comparison with the constant fact values. The definition of plan values is not clear for the members of the various expert groups either, but by applying the membership functions, this subjectivity becomes manageable and integrable. Through all of this, the value judgments determined by standardized norms with different plan values become comparable and thus can be evaluated in relation to each other. Different value judgments can result in different intervention points for the examined KPIs. For example, if the 1ST's value judgment of "KPI A" is critical, but the 2ST's value judgment of "KPI A" is acceptable. In this case, "KPI A" is a KPI to be developed based on the value judgment of the 1ST, while "KPI A" does not require intervention during the value judgment of the 2ST. If the development of the fact value belonging to "A KPI" results in a category change in the performance evaluation according to 1ST, it does not necessarily involve a change of category in the performance evaluation according to 2ST. If the 2ST value judgment of "KPI A" is excellent, in that case, any improvement in the fact value of "KPI A" will not result in a category change.

One of the most significant limitations of the model is that our model does not use the standardized norms that serve as benchmarks in an integrated form. As a result, organizations are unable to make effective decisions based on the information provided by the model. Our model does not give feedback on the level of sustainability with one peak indicator but with three different peak indicators. Because of the applied standardized norms of the same value, managerial decision-making becomes complex and unclear.

Disadvantages from the subjective definition of the KPI's plan value and weight values appear in the model. These values have a significant impact on the performance evaluation of the organization's sustainability level. So reducing subjectivity makes the model more accurate. Another defining limitation of the model comes from the methodology of fuzzy logic. In the event that the data included in the input functions of the fuzzy logic are extreme, i.e., the standard deviation of the data is extremely high, then the methodologies based on fuzzy logic do not provide an interpretable value judgment. In our model, the values of the KPIs were determined as plan-fact ratios. The plan values were determined by the different expert groups; thus, the risk of extreme values appearing in the model is very high for the plan values defined by the sustainability expert groups (2ST and 3ST). At the same time, in the case of plan values (1ST) determined by company managers, the risk of extreme values appearing in the model can be managed since the plan values are adjusted by the managers to the company's strategy and capacities. The plan values defined in this way are based on the decision of the managers and can, therefore, be more influenced than the plan values defined by the sustainability expert groups (2ST and 3ST).

Our model is not suitable for exploring the vertical and horizontal relationships of the indicators; it is only suitable for evaluating the performance of the indicators. By defining the explanatory variables, the model would provide more detailed information content and more accurate feedback in the exploration of intervention points. By clearly identifying the explanatory variables and improving their values, the level of organizational sustainability can be increased even more significantly and dynamically than by improving the critical results obtained in the current model.

Due to the difficulty of obtaining information, the model is not suitable for industry comparative analysis. The reason for this is that similarly structured internal data are not shared publicly, and the evaluation of the sustainability level must be based on company-specific KPIs, which can be used to achieve a value judgment that approximates reality.

There are some factors to highlight among the model's development options:

- The weighted average calculation used as an aggregation method can be distorting; it is advisable to use other mathematical and statistical methods to deal with this. In addition to the average calculation, statistical methods suitable for dimension reduction, such as cluster analysis, may also be suitable. In addition to aggregation, such statistical methods are also suitable for exploring explanatory variables. At the same time, it is important to highlight that the threshold values of the reliability indicators must also be met during the multivariate statistical analyses. If this condition is not met, aggregation cannot be applied. The definition of the aggregation areas is not based on predefined groups but is created based on the exploration of the cause-effect relationships of the KPIs included in the analysis.
- The application of the Takagi–Sugeno fuzzy method can reduce subjectivity.
- To increase objectivity and accuracy and to reduce the use of different standardized norms, the neurofuzzy method can be an effective solution.
- The fact data as a predictive value and the plan value as a plan value for the period of the predictive fact data are included in the analysis; then, the model can be developed into a predictive one by applying this plan-fact analysis ratio. The integration of non-linear methodologies during predictive modeling can make the accuracy of the model and its practical application more effective.

A further research possibility is the implementation of the model we have developed in relation to the operating processes of other similar industry organizations and the expansion of the model with other standardized norms. The plan values for supply chains can be defined as a standardized norm, with which the level of sustainability can be increased not only within the organization but also within the supply chain. The evaluation based on the consumer value judgment can serve as an additional standardized norm through which the customer's expectations and values are also reflected in the performance evaluation. In addition to these, a benchmark created by mathematical methods can be used as a standardized norm, which integrates and weights the norms used so far, thereby reducing subjectivity and increasing accuracy. The application of the neurofuzzy method can create appropriate standardized norms, which can be used to refine the model, but an understanding of the norm created in this way can be a challenge for decision-makers.

We also recommend harmonizing industry data, professional organizations and the opinions of company managers, thereby creating generally valid reference values and classification thresholds.

The model we have developed can be used in many other areas in which subjectivity and differences in expert opinions are significant. Among these areas, the performance evaluation of lean management, the risk evaluation of investment portfolios, the evaluation of the level of animal welfare, the evaluation of the success of projects, the evaluation of the performance of athletes and the evaluation of the use of European Union financial resources at the national level should be highlighted.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15107981/s1, Questionnaire S1: Weight values of the KPIs. Title Weight values of the KPIs. Questionnaire S2: Classification thresholds values of the KPIs.

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