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Organization Performance Composite Index Under Fuzziness: Application on Manufacturing Organization

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Abstract
Measuring the organization's performance is essential for continuous improvement and operational excellence. Appropriate organizational measures include multiple dimensions. The relative importance of the multiple dimensions varies depending on the organization's context and the management team's visions. The vagueness and ambiguity in the management team's perspective toward the dimensions and associated sub-indicators show fuzzy property. This paper aims to synthesize the overall organization performance in one aggregated index, engage the management team through index formulation, deal with ambiguity and vagueness in the management team perspective using fuzzy mathematics, and use the synthesized index in monitoring and controlling the organization's performance to achieve operational excellence. The proposed approach is implemented in manufacturing organizations to prove practicality. The implementation of the proposed method shows a positive impact on the organization's performance monitoring as the management team focused on one measure. Furthermore, it has engaged the management team in selecting and weighing the leading group and associated KPIs. The R programming and Minitab 19 are used in the collected data processing.

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1. Introduction

There is no doubt that globalization affects the work environment around the world. Competition becomes much more potent, customer requirements become complicated, and the rate of change in all business elements becomes very high. Thus, most organizations are forced to face challenges to increase their levels of customer satisfaction and reduce operating costs, simultaneously reducing the lead time to reach the items to the market.

To meet those challenges, organizations must develop an efficient performance measurement system to measure current performance and be a baseline for improving future performance. The rate of change in technology, materials, information, currency, and oil prices increases the risk in the decision-making process and needs a structural way of decision-making. Under this circumstance, continuous improvement is not a choice; it is an essential part of the organization's strategic objectives to survive.

All these factors increase the pressure on the organizations and lead to an increase in the importance of organization performance monitoring and control so that representing the overall organization performance in one index will support the assessment of the organization's current performance, define the baseline for future performance and help the organization management team to precisely define the best directions.

The organizations need to determine the relevant indicators based on size and the nature of the organization. The selected indicators should support organizational goals and objectives. The performance measurement should assess the efficiency of the performed activities and tasks within the organization. The performance measurement should declare the performance gap between the organization's current performance and the required performance.

Products and services need to be constructed faster, cheaper, and of better quality. The triple constraint is an essential project management concept that frames the project's scope by quality, cost, and time as shown in Figure 1. This paper selected the triple constraints as the leading performance dimensions. Quality is the main coemption area in today's environment, and the quality is expanded through the last century with the industrial area. Starting from the inspection to detect defective products, moving to quality of the system and process to prevent the defects caused the occurrence, and ending with total quality management aiming to get complete customer satisfaction by considering cost and delivery time.

The total quality management and lean manufacturing concepts can be considered the backbone of the excellence models. The standard excellence models are Malcolm Baldrige, EFQM, and Shingo models. The common themes of all excellence models are leadership, engaging people, focusing on process, achieving maximum value to customers, and delivering results to stakeholders. So that the performance measurement should get as much as possible consensus from the organization management team. Engaging the management team is considered crucial for achieving the required results via participation in developing the organization's performance measures. Different points of view come from different backgrounds, personalities, knowledge, and responsibilities, and those factors lead to ambiguity in the relative importance of the key performance indicators.

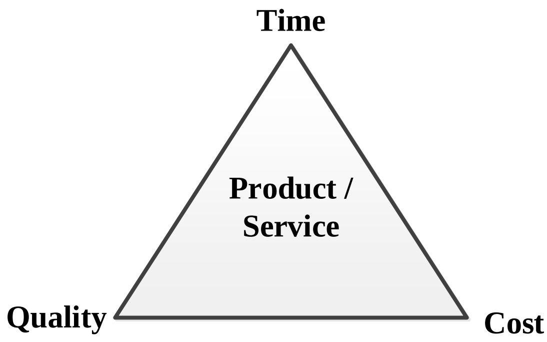

Fig. 1. Triple constraint for product or service (Richardson, 2020)

Fuzzy mathematics is a mathematical branch based on the contribution of Zadeh (1978). Fuzzy mathematics deals with ambiguity and vagueness of concepts in which the element belongs or does not belong to the set but it has a partial inclusion in the set. He replaced the two extremes of classical logic, "completely true" or "completely false," with a continuous range of values between 0 and 1. Membership The degree of inclusion to a set. Fuzzy sets have values between 0 and 1 that indicate the degree to which an element has membership in the set. The degree 0 means that the element has no membership; at one, it has full membership. The fuzziness in the proposed method during assigning weights reflects the relative importance of the KPIs.

2. Literature review

Several works of literature deal with the performance of an organization and its related dimension and decision-making process under fuzziness. Some literature presented attempts to integrate multicriteria decision-making methodologies to support the organization management team.

Tudose et al. (2022) assessed the determinants of financial performance, measured based on four generations of indicators. The study provides a quantification of interdependencies between different financial performance measures such as profit margin (PM), profit growth rate (PGR), return on assets (ROA), return on equity (ROE), and economic value added (EVA). Bernardo et al. (2022) developed a method that integrates multiple management tools for organizational excellence in medium and large enterprises. The method was developed considering tools and concepts well-established in the literature, such as Lean Thinking, Six Sigma, and Balanced Scorecard, among other management tools. Czerwińska and Pacana (2022) studying manufacturing enterprises in the context of process monitoring maturity determined the level of maturity in the use of process monitoring techniques and methods in manufacturing enterprises. Tomov and Velkoska (2022) presented a framework of contemporary quality costs concept contributing to a more sustainable society regarding an integrated view of quality costs in all phases of the product life cycle (engineering, production, use, and end-of-life) by all stakeholders in the supply chain. Krynke (2021) proposed a method to support decision-making from a cost management perspective in the initial production planning stage. Siwiec and Pacana (2021) presented a framework that supports improving product quality by precisely identifying the incompatibility and root of their occurrence, including solving the decision problem. They claimed that the use of brainstorming, cause and effect diagram, the AHP method (Fuzzy Analytic Hierarchy Process), and the 5Why method would be allowed to effectively identify the root of the problem. Gupta et al.(2021) identified the essential practices of Green Human Resource Management (GHRM) and evaluated the performance of manufacturing organizations using GHRM practices. He suggested a three-phase methodology. The first phase involves identifying GHRM practices in manufacturing organizations through the literature review and expert opinion. The second phase involves ranking GHRM practices using the Best Worst Method (BWM). The third phase involves evaluating manufacturing organizations based on GHRM practices using the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Hassan and Jaaron (2021) investigated the underlying relationship between total quality management (TQM) and the level of green manufacturing (GM) practices implementation in Palestinian food manufacturing companies (PFMC). Hamann and Schiemann (2021) presented an empirical analysis for developing organization performance in four dimensions. Wiedenmann & Größler (2021) developed an approach to measuring risk exposure in manufacturing supply networks. Kaldas et al. (2020) developed a framework for assessing the sustainability of manufacturing organizations. The composite sustainability index covers the triple bottom line approach and the total life cycle stages. Kynčlová et al.(2020) developed a composite index to measure achieving industry-related targets of Sustainable Development Goal 9 (SDG-9). The index measures a country's progress toward achieving industry-related targets of Sustainable Development Goal 9 (SDG-9). Dolge et al. (2020) presented a sub-sectoral comparison and proposed a composite index for industrial sector energy efficiency evaluation. They concluded that there is enormous potential for energy efficiency improvements in energy-intensive sectors such as wood and non-metallic mineral manufacturing. Eskandari et al. (2021) established a scale of validation and assessment of the elements that affect the organization's safety. They used the fuzzy analytic network process (FANP) to weigh the estimation of the elements and to reveal the influence of various structures for the proposed scales on the safety performance indicator. An and Kim (2019) studied the factors that impact the Financial Performance of the Korean Automotive Parts Cooperation**.** The study classified factors to control and independent variable. The control variables are the business period, export size, and capital size. The independent variables are grouped into company size, business diversification, and experience in the overseas market. The study investigated the relationship between the selected independent variables and the independent variable (sales). Eskandari and Jabbari Gharabagh (2019) developed a sustainability index for Mauritian manufacturing companies. The study reveals an index with nine environmental, four economic, and two social indicators pertinent to sustainability measurement, varying degrees of importance, within the Mauritian manufacturing context. Adane and Nicolescu (2018) developed a framework (generic) modeling approach for modeling the structure of the machining system parameters of the poring process, key performance parameters, and their intrinsic relationships. Navimipour et al. (2018) proposed a model for examining the role of influential factors on the performance of organizations. The model investigates the effect of organizational culture, Information Technology (IT), and employees satisfaction on the organization's performance. Furthermore, it evaluates the relationships between these variables and organizational performance. Dickel and Moura (2016) developed a model measuring organizational performance focusing on knowledge and innovation management. They used a quantitative research study, a multi-case study applied to three companies in the metal-mechanic sector in southern Brazil. The methodology uses the assumptions of well-known methods such as the Key Performance Indicators, the Swing Weighting, and the Simple Attribute Rating Technique. Rajak and Vinodh (2015) used fuzzy logic for sustainability performance evaluation and applied the approach to Indian automotive component manufacturing organizations. Hosseini Ezzabadi et al. (2015) presented a new integrated approach based on the EFQM model using Fuzzy Logic, Analytical Hierarchy Process (AHP) technique, and Operations Research (OR) model to improve the organizations' excellence level by increasing the quality of the business performance evaluation and determining improvement projects with high priority. Bergeron et al.(2004) studied the deployment and translation of information technology (IT) and its impact on performance increases.

Through the literature review, efforts to develop indexes to evaluate organizations' sustainability, energy consumption, and green human resources can be found. Furthermore, integrating fuzzy multicriteria decision-making such as AHP and TOPSIS support organizational situations. Some literature tried to correlate green manufacturing and TQM. There is work in one literature that tried to use fuzzy AHP to improve the organization's excellence level.

There is a gap in the literature in developing a composite index related to organizations' core business, such as the quality of products and services, cost of process elements, and delivery time. Engagement of the organization management team is absent from the focus of the literature.

This paper tries to resolve the issue of how an organization's performance measure can be aggregated with different perceptions of the management team. Moreover, how we engage the management team and let them own the synthesized index and use it to measure and improve the organization's performance.

This paper aims to develop a composite organizational measure to aggregate the multiple dimensions considering the fuzziness in the preferences of the management team. Collecting the preferences of forty-one members of the organization's senior management team and representing the relative importance of the performance dimensions and sub-indicators as a triangular fuzzy number and converting the fuzzy number to an interval using different alpha cuts. Furthermore, using the weight intervals to construct a composite organization index. The proposed approach is implemented in manufacturing organizations to prove practicality.

3. Methodology

The formulation of a composite index goes through sequential steps; the first step is to decide the dimensions of the overall performance index, which will be named as leading groups in the rest of this paper; the leading groups are defined based on the concept of the triple constraint which is borrowed from project management so that the leading groups will be quality, cost, and time (delivery). Under each leading group, the management team selects an appropriate number of associated KPIs. A series of weights should reflect the leading group's relative importance to the overall organization's performance. And the relative importance of each KPI to the leading group. The composite performance index can be calculated based on the weights and KPI score. The selected method is budget allocation (BA), where 100 points are given to each management team member, and she/he distributes the points reflecting their point of view of the relative importance of the leading group regarding overall organization performance and for each KPI regarding the leading group. The collected weights for each leading group and sub-indicator will be transformed into a triangular fuzzy number to deal with the impressions of the weighting process. Then the alpha cuts are taken for each fuzzy number, and the resulting values are used to calculate the main groups and overall organization scores.

$$EI(A) = [EI_L(A),, EI_u(A)] = \left[\int_0^1 A_L(\alpha)d\alpha\, , \int_0^1 A_U(\alpha)d\alpha\right] \qquad (1)$$

Where: A is a fuzzy number $EI(A)$ is the expected interval of A.

$$EV(A) = \frac{EI_L(A)+EI_u(A)}{2} \qquad (2)$$

Where: $EV(A)$ is the midpoint of the expected interval and is also called the expected value of the fuzzy number

After the weighting process is completed, the data is collected and normalized using one of the normalization techniques. The normalization is required due to different units of measure of KPIs. The linear max-min normalization is used in equation 3 for beneficial KPIs and equation 4 for non-beneficial KPIs.

$$\overline{X}_{ij} = \frac{X_{ij}-X_j^{min}}{X_j^{max}-X_j^{min}} \quad (3)$$

$$\overline{X}_{ij} = \frac{X_j^{max}-X_{ij}}{X_j^{max}-X_j^{min}} \quad (4)$$

Where: $\overline{X}_{ij}$ is the normalized value, X_{ij} is the original value of the KPI, X_j^{min} is the minimum score of KPI j, and X_j^{max} is the maximum score of KPI j.

After normalization, the additive aggregation is used to formulate the overall and leading group's scores. The main group and overall organization scores are used to monitor organizational performance.

$$OPI = \sum_{i=1}^{n} W_i \, \mathrm{PI}_i \quad (5)$$

Where: OPI is the overall organization performance, W_i is the weight of the leading group, and PI_i is the score of the leading group.

4. Experimental (Practical application)

The proposed approach will be applied to a manufacturing organization. The manufacturing organization used for the application is one of the manufacturing companies in Egypt with a number of laborers around 5000, and the company exports its products exported worldwide. The system of work in manufacturing makes to order, and the company produces textile products. The organization faces many challenges regarding cost, quality, and delivery in international competition, so the implementation of the proposed method seems suitable.

4.1. Leading groups and KPIs selection

The triple constraint concept will define the leading groups because it is well-known, simple, and generic. The three leading groups will be quality, cost, and time (delivery). So based on the size and nature of the organization, business, and the desired performance level management team should select a group of KPIs under each of the three leading groups quality, cost, and time. Many sources of KPIs can be used as KPIs tanks to select the most appropriate group of KPIs that match the organization's strategic objectives. The three leading groups' quality group of KPIs (Q_i), the cost group KPIs (C_i), and the time group (T_k) and leading group associated KPIs presented are.

- Number of reworks orders = number of cases where the finished goods did not complete the minimum allowance of the customer rules of shipment and needed a new order to compensate for the difference
- Rework % = Average rework % per order per month
- Right first time = $\frac{Total\ Accepted}{Total\ Produced} * 100$
- Overproduction = $\frac{Excess\ production}{order\ Quantity} * 100$
- In full= $\frac{No\ of\ orders\ shipped\ on\ time}{total\ number\ of\ order} * 100$
- OTD= $\frac{No\ of\ orders\ shipped\ on\ time\ and\ the\ comple}{te\ total\ number\ of\ order} * 100$
- OTD: On-time Delivery.
- All cost measures are the monthly cost of the items (Note: Money in Egyptian pounds and quantities in square meters)

4.2. Assigning Weights

After selecting the leading groups and the KPIs associated with each group, formulating the overall performance index needs appropriate weights to be assigned for each KPI and the leading group. These weights should reflect the importance of each KPI concerning the leading group and the importance of leading groups concerning overall organization performance. The resulting weights are based on the budget allocation given to 41 senior management team members in the manufacturing organization. The collecting weights are presented in Appendix A and visualized in Figures 2 to 5.

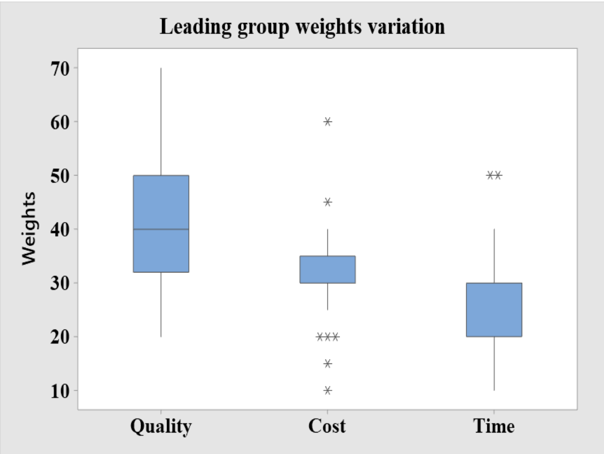

Fig. 2. Box plot of the leading group weights

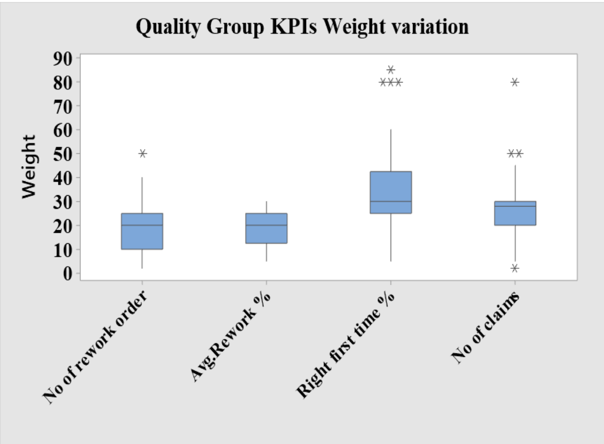

Fig. 3. Box plot of quality KPIs weights

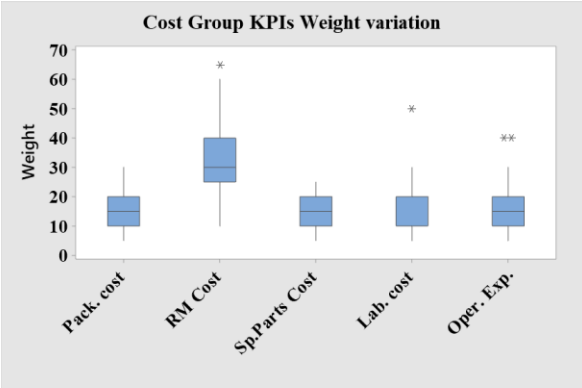

Fig. 4. Box plot of cost KPIs weights

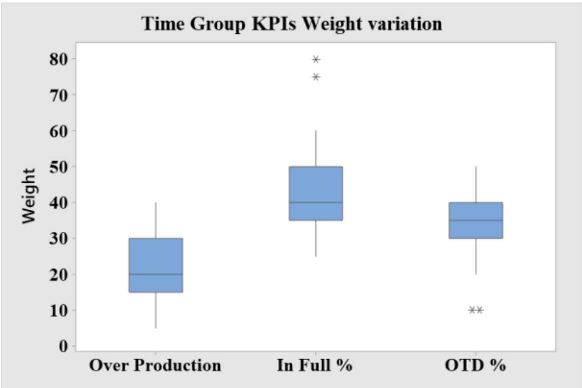

Fig. 5. Box plot of delivery(time) KPIs weights

4.3. Converting weights to fuzzy number

The collected weights show variance in the opinions of the management team and reflect the imprecision weighting process. The fuzzy triangular numbers can represent the vagueness and variation weighting process. The fuzzification will depend on the weights' minimum, median, and maximum values. The results of collected weights for the leading group and associated KPIs are presented in Table 1. The fuzzy number membership function is presented in Figure 6 to Figure 9.

Table 1. The collected weights

Main group and KPIs	Minimum	Median	Maximum
(Q)Quality	20	40	70
(C)Cost	10	30	60
(T)Time	10	30	50
(Q_1)No of Rework order	2	20	50
(Q_2)Avg, Rework %	5	20	30
(Q_3)Right first time	5	30	80
(Q_4)No of claims	2	28	80
(C_1)Packaging cost	5	15	30
(C_2)RM cost	10	30	65
(C_3)Spare Parts cost	5	15	25
(C_4)Labor cost	5	20	50
(C_5)Op. EXP	5	15	40
(T_1)Over Production	5	20	40
(T_2)IN FULL	25	40	80
(T_3)LTD	10	35	50

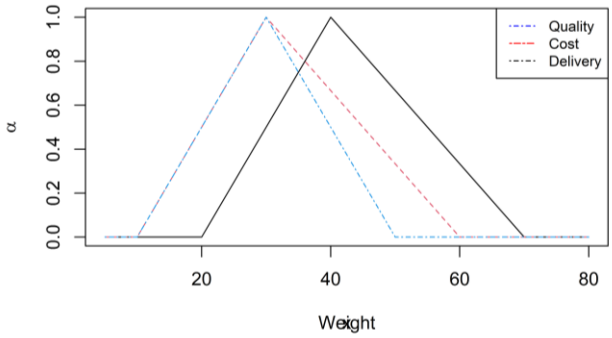

Fig. 6. Main groups fuzzy numbers

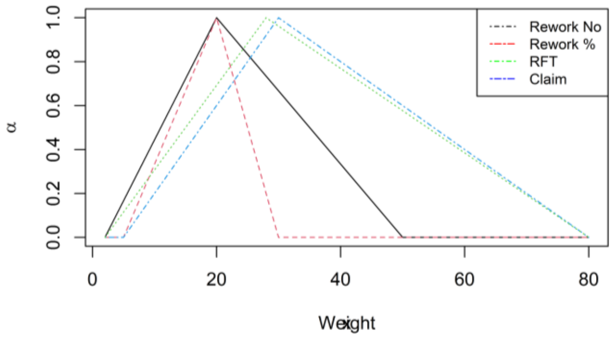

Fig. 7. Quality KPIs fuzzy numbers

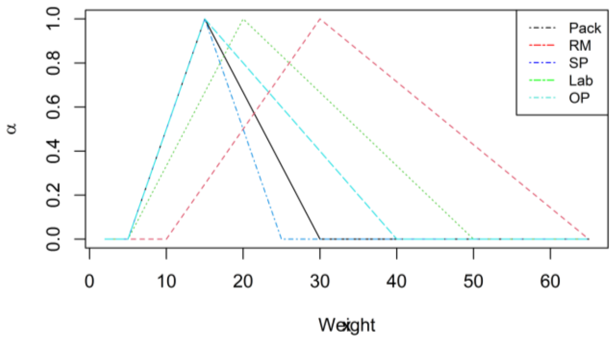

Fig. 8. Cost KPIs fuzzy numbers

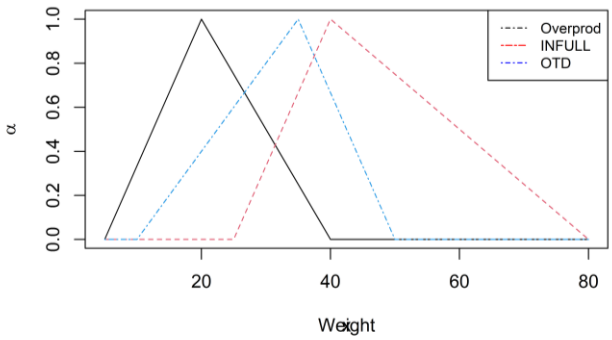

Fig. 9. Delivery KPIs fuzzy numbers

4.4. Apply alpha cut at different value

Typical values of expected intervals based on alpha cuts are calculated, and the midpoint of the expected value of each alpha cut will be used as a weight for each leading group and sub-indicator. This paper calculates alpha cuts at 0.2, 0.5, and 0.8. The typical value and midpoint of the expected interval are calculated based on equations 1 and 2 (Dubois & Prade, 1987) . The values calculation is presented in Table 2. The used weight is an average of three midpoints and three alpha cuts.

Table 2. The typical value and midpoint at three alpha cuts

Leading groups and KPIs	Intervals values at three alpha Cuts					
	$U_{0.2}$	$L_{0.2}$	$U_{0.5}$	$L_{0.5}$	$U_{0.7}$	$L_{0.8}$
Quality	24	64	30	55	34	49
Cost	4	54	20	45	24	39
Delivery	14	46	20	40	24	36
Rework Number	5.6	44	11	35	14.6	29
Avg Rework %	8	28	12.5	25	15.5	23
RFT	10	70	17.5	55	22.5	45
Claim Number	7.2	69.6	15	54	20.2	43.6
Pack Cost	7	27	10	22.5	12	19.5
RM Cost	14	58	20	47.5	24	40.5
SP Cost	7	23	10	20	12	18
Labor Cost	8	44	12.5	35	15.5	29
OP Cost	7	35	10	27.5	12	22.5
Overproduction	8	36	12.5	30	15.6	26
IN FULL	28	72	32.5	60	35.5	52
LTD	15	47	22.5	42.5	27.5	39.5

4.5. Data collection and normalization

The data was collected for each sub-indicator (KPIs) for 34 months, and the KPIs are normalized based on the benefits of the KPI (Beneficial and non-beneficial). The original and normalized data are presented in Appendix B and Appendix C.

4.6. Leading groups and overall organization scores

The Leading group scores are calculated based on the weights of sub-indicators and KPIs, and the overall organization performance score is calculated based on the leading group weights and scores. The leading group's weights are scaled to one for overall organizational performance, and the associated KPIs weights are also scaled to one for each leading group. The scores of the leading group and overall organization performance scores are presented in Table 3, Figure 10, and Figure 11.

Table 3. The average leading group and overall score

Month	Quality	Cost	Delivery	Overall
Mar-19	0.736	0.926	0.680	0.775
Apr-19	0.559	0.772	0.799	0.691
May-19	0.594	0.800	0.677	0.678
Jun-19	0.618	0.854	0.352	0.610
Jul-19	0.745	0.922	0.524	0.732
Aug-19	0.650	0.538	0.461	0.561
Sep-19	0.795	1.012	0.527	0.781
Oct-19	0.676	1.012	0.672	0.774
Nov-19	0.466	0.840	0.689	0.641
Dec-19	0.674	0.569	0.734	0.659
Jan-20	0.561	0.493	0.672	0.572
Feb-20	0.600	0.891	0.564	0.676
Mar-20	0.705	0.492	0.550	0.595
Apr-20	0.620	0.609	0.546	0.594
May-20	0.558	0.650	0.532	0.577
Jun-20	0.519	0.001	0.492	0.356
Jul-20	0.208	0.552	0.618	0.429
Aug-20	0.469	0.681	0.752	0.613
Sep-20	0.371	0.770	0.749	0.599
Oct-20	0.518	0.892	0.687	0.677
Nov-20	0.528	0.850	0.587	0.640
Dec-20	0.409	1.004	0.541	0.624
Jan-21	0.534	0.889	0.716	0.692
Feb-21	0.691	1.214	0.732	0.858
Mar-21	0.629	1.138	0.611	0.775
Apr-21	0.396	1.152	0.667	0.699
May-21	0.578	1.065	0.731	0.766
Jun-21	0.534	0.853	0.824	0.712
Jul-21	0.627	0.778	0.703	0.693
Aug-21	0.486	0.924	0.719	0.683
Sep-21	0.311	1.141	0.610	0.644
Oct-21	0.469	1.041	0.563	0.666
Nov-21	0.491	1.119	0.661	0.726
Dec-21	0.262	1.040	0.535	0.573

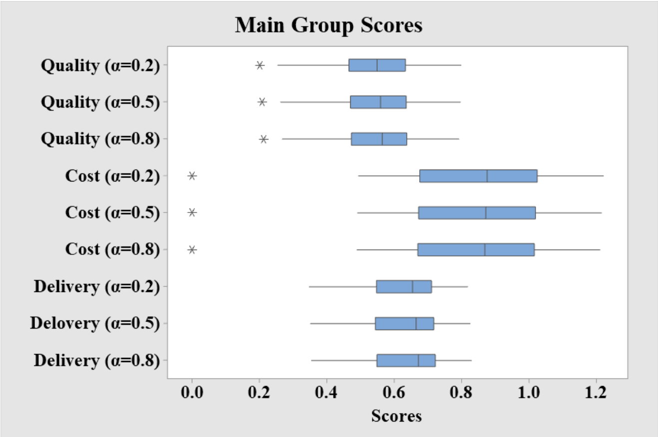

Fig. 10. Box and Whisker plot of Leading-group scores

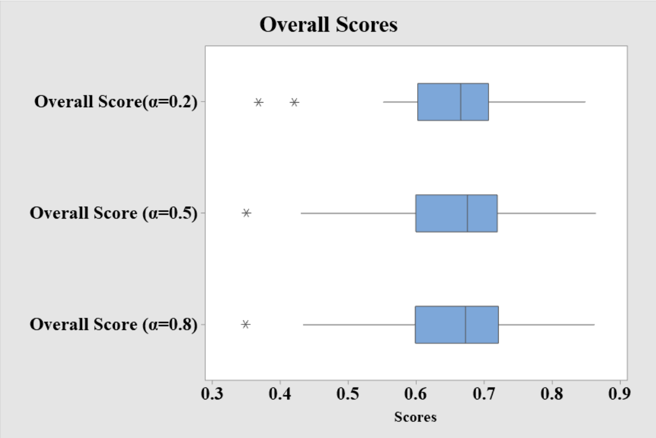

Fig. 11. Box and Whisker plot of overall organization scores

4.7. Monitoring the leading group and overall organization performance

The leading group and overall organization performance scores were monitored to assess the organization's progress. The data is collected regularly. The shorter period is better due to the ability to early action in case of unacceptable performance. The management decides to monitor the performance monthly. There are many methods of monitoring and controlling the scores. The individual control chart will monitor the organization's leading group and overall score. The control chart is a graphical method used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit. Furthermore, the upper and lower control limits are calculated to be three standard deviations from the central line. The individual control chart is presented in Figures 12 to 15.

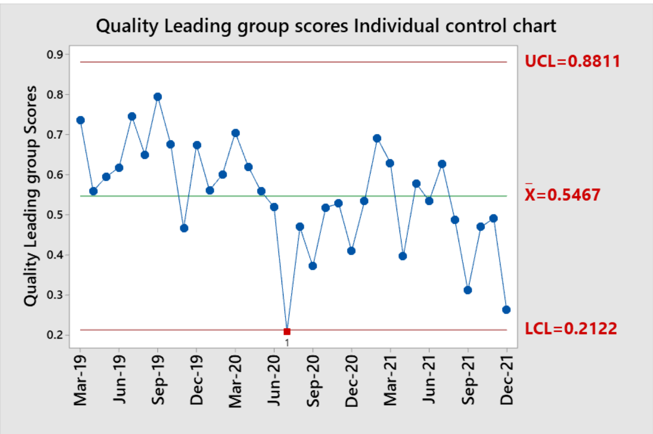

Fig. 12. Quality leading group scores individual control chart

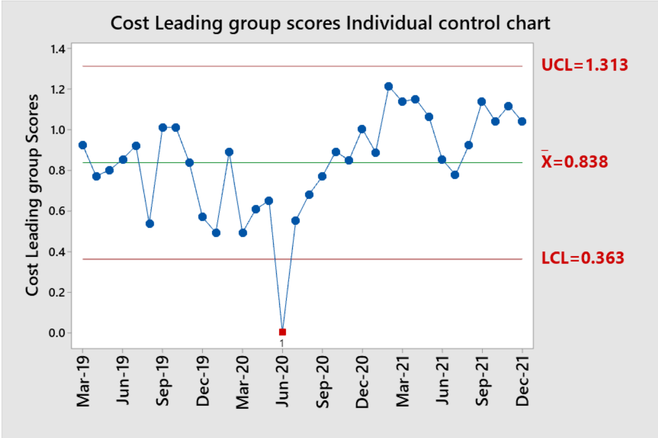

Fig. 13. Cost-leading group scores individual control chart

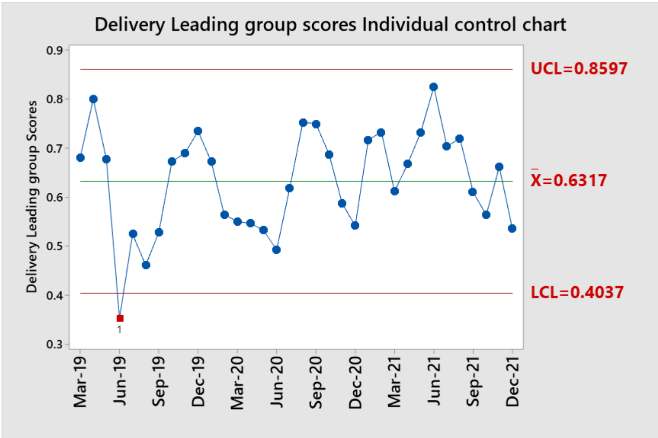

Fig. 14. Delivery leading group scores individual control chart

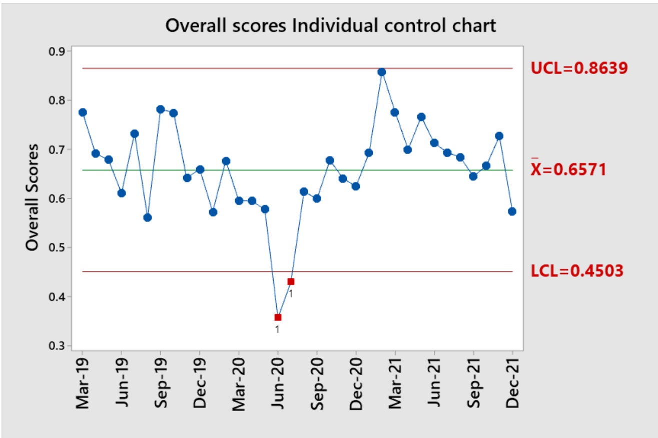

Fig. 15. Overall scores individual control chart

The control chart was evaluated to check the stability of the leading group and overall performance. The out-control points were investigated to identify the causes of deviation. The management team develops corrective actions to eliminate, adjust, and circumvent the root causes of deviations. For example, the point of July 2020 went below the lower control limits in the leading quality group. The team investigates the situation and found that the number of rework orders and average rework percentage are high at these points. Quality control data are analyzed to determine which defects impact the product rejection rate, and problem-solving activity is applied to identify the root causes and set of corrective actions during the processing to prevent critical defects from the occurrence. Furthermore, assessing control charts for up-normal variability should be used as an early warning for performance deviations.

The individual control chart is mainly focused on assessing the accuracy of performance measures. If the organization needs to assess the precision of the performance measure, the moving range (MR) chart can be used for this purpose. Based on the evaluation of the management team, the individual control chart will be enough at the beginning of the implementation of the methodology.

5. Results and discussion

The proposed method offers an interactive approach to represent the overall organization performance in a composite measure based on three leading groups. The approach is based on selecting three leading groups quality, time, and cost. The three leading groups are used for the suitability of most organizations. The management team selects associated KPIs under each leading group. The relative importance from a management team's point of view was collected using a questionnaire sent to forty-one senior managers. The variability of the collected weights shows fuzziness and prosperity. The triangular fuzzy number was selected to represent the weights based on minimum, median, and maximum scores. Three alpha cuts are used to convert the fuzzy number as intervals, and the average weight is used to formulate the composite index. Thirty-four data points are collected from the organization database for testing the approach.

The data were normalized using the linear max-min normalization technique to handle different units of measure. The additive aggregation is used to formulate the composite index of the leading group and overall organization performance score. Geometric aggregation or hybrid aggregation techniques can be used based on the degree of compensability among sub-indicators. In contrast, linear aggregation rewards base indicators proportionally to the weights and geometric aggregation rewards category with higher scores (so compensability is lower for the composite indicators with low values), given these considerations and the advantage of the geometric aggregation in avoiding factor substitutability. The individual control chart is used for the leading group and overall performance monitoring and the moving range chart can also be used in monitoring the precision of performance measures. The application shows the effectiveness of the proposed approach in representing the organization's performance in one composite measure-furthermore, the flexibility of using a leading group, normalization techniques, and aggregations method. The variation is expressed using the fuzzy number, and there is flexibility in selecting alpha cuts for the defuzzification of the fuzzy numbers. There are some limitations in the presented case study, such as the selected KPIs focused only on operational measures, and the human resources and intangible measures are not considered within the presented case. The selection of the Leading group can be extended in further studies to add more groups such as human factors, marketing, and sales.

6. Summary and conclusion

The performance measure is one of the most critical aspects of today's business management activity, and representing the organization's performance in one measure represents the overall organization performance and is a critical facilitator to the continuous improvement of performance. In this paper, the overall organization performance index is formulated based on the triple constraint and preferences of the management team in the organization. The fuzziness in assigning weights is considered in detecting the weight of leading groups and sub-indicators. The additive aggregation aggregates the main groups and overall organization performance. The individual control chart monitors and controls the leading synthesis group and overall organization performance. The proposed method shows flexibility in selecting the main groups and associated KPIs. The selection process depends on the organization's strategic objectives and the selected excellence framework. The common frameworks are Malcolm Baldrige, EFQM, and the Shingo model. The Leading groups and associated KPIs change based on the structure of the selected framework. Implementing the proposed method in the presented organization positively impacts the organization's performance due to the management team engaged in selecting KPIs and leading groups. The management team contributes by assigning weights to the leading groups and KPIs. The management team monitors one measure monthly, and this measure can be cascaded to the leading group and group of KPIs, which enhances the problem-solving process. There are some limitations in the presented case process, such as the three leading groups are common to all organizations. However, in some cases, the leading groups need to be more and cover more dimensions, especially the human factor, which shows explicit fuzzy nature in assessment.

For future research, the proposed approach can be extended by using different normalization techniques, geometric aggregation, defuzzification methods, and using a different type of control chart to monitor the results. In selecting the leading group, the human and behavioral dimensions will be helpful to investigate.

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模糊下的组织绩效综合指标：在制造组织中的应用

關鍵詞
模糊下的性能测量
综合指数
绩效改进卓越模型

摘要
衡量组织的绩效对于持续改进和卓越运营至关重要。 适当的组织措施包括多个方面。 多个维度的相对重要性因组织环境和管理团队的愿景而异。 管理团队对维度和相关子指标的看法的模糊性和模糊性表现出模糊性。 本文旨在将组织的整体绩效综合到一个综合指标中，通过指标制定让管理团队参与进来，用模糊数学处理管理团队视角中的歧义和模糊，并将综合指标用于组织绩效的监测和控制。 实现卓越运营。 所提出的方法在制造组织中实施以证明实用性。 由于管理团队专注于一项措施，因此建议方法的实施对组织的绩效监控产生了积极影响。 此外，它还让管理团队参与选择和权衡领导小组和相关的 KPI。 R编程和Minitab 19用于收集的数据处理。