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A comprehensive evaluation of a company performance using sustainability balanced scorecard based on picture fuzzy AHP

Buse Duygu Dağıdır, Barış Özkan *

Department of Industrial Engineering, Ondokuz Mayıs University, 55139, Samsun, Turkey

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ABSTRACT

The Balanced Scorecard (BSC) is a performance management tool that analyzes the relationship between tangible and intangible assets. Its ability to render business strategy visible has earned it the distinction of being a strategic management model. Sustainability has become an important part of daily and business life today. With the increasing importance given by stakeholders to environmental and social issues, companies find it necessary to evaluate sustainability activities in their performance evaluations. In order to meet this need, the Sustainability Balanced Scorecard (SBSC) emerged with the addition of a sustainability perspective or parameters to BSC. The number of academic studies pertaining to the application of BSC, which numerous companies and subjects to research have utilized, is inadequate. Due to its hierarchical structure and the necessity to evaluate numerous criteria, BSC is suitable for using multi-criteria decision-making (MCDM) methods. In this paper, an integrated approach consisting of SBSC, the Picture Fuzzy Analytic Hierarchy Process (PF-AHP), and the Objective Matrix (OMAX) method is proposed for the performance measurement of companies. The PF-AHP method has been reorganized for ease of application in determining the perspectives, strategic objectives, and Key Performance Indicators (KPIs) weights within SBSC. Additionally, the OMAX method has been employed for calculating the performance scores. This proposed approach was implemented in a factory operating in the glass industry. The SBSC created for the company includes five perspectives, 16 strategic objectives, and 34 KPIs. PF-AHP method was used to determine the weights of perspectives, strategic objectives, and KPIs to be used in the performance score calculation with OMAX. The weight of financial perspective is 0.267, the weight of the customer perspective is 0.247, the weight of the internal process perspective is 0.191, the weight of the learning and development perspective is 0.161, and the weight of the sustainability perspective is 0.134. The evaluations made by the decision-makers indicate that the company's performance measurement still adheres to the traditional framework. The performance score of the company is 6.14 out of 10.

1. Introduction

The concept of sustainability, which includes economic, social, and environmental perspectives, has become an important issue in today's world in order to cope with global challenges such as increasing poverty and climate change. This situation has brought pressure from stakeholders on terms of sustainability. At this point, the concept of corporate sustainability has emerged. Corporate sustainability is defined as meeting the needs of its direct and indirect stakeholders without compromising its ability to meet their future needs, taking into account both the administrative and operational activities of the organization (Nicoletti Junior et al., 2018). In addition, corporate sustainability also stands out as systematic management efforts for companies to voluntarily integrate environmental and social issues into management (Hansen and Schalteggar, 2016).

National and international legislation on sustainability perspectives is being developed (Kaplan and Norton, 2004), but reporting of social and environmental activities is still voluntary for companies (Huang et al., 2014). However, the importance given to the concept of sustainability will create a difference among competitors (Nicoletti Junior et al., 2018).

For a company to be successful in terms of corporate sustainability, it is not enough to be successful in a single perspective of sustainability. Corporate sustainability aims for companies to make progress in all three perspectives of sustainability (economic, environmental, and social) (Eifert and Julmi, 2022). Companies adopt environmental

* Corresponding author.
E-mail addresses: buseduyguyangin@gmail.com (B.D. Dağıdır), baris.ozkan@gmail.com (B. Özkan).

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management systems practices to achieve the goals they set in order to meet the social and environmental expectations of stakeholders. However, these applied environmental management systems cannot fully reveal the contribution of sustainability performance to economic performance (Tsalis et al., 2013). As technological developments towards sustainability are increasing, companies need an effective tool to achieve their sustainability goals (Al-Mawali, 2023).

BSC is a multidimensional performance measurement method developed in the early nineties by Robert S. Kaplan, an accounting professor at Harvard University, and David P. Norton, a consultant specializing in performance measurement, strategy, and restructuring for companies (Kaplan and Norton, 1996a). BSC, one of the most important management tools of the twentieth century, has been studied by various disciplines over the past 30 years still maintains its popularity (Tawse and Tabesh, 2023). The traditional BSC model consists of four perspectives: financial, customer, internal processes and learning and development, which are directly related to company strategy (Epstein and Wisner, 2001). Although the four perspectives are found to be sufficient for many sectors, these four perspectives should be considered only as a pattern. Depending on the sector of activity, companies may use three of the four perspectives or add one or more perspectives (Kaplan and Norton, 1996a).

BSC is a popular method to evaluate business performance, but in traditional BSC, the effect of sustainability in performance evaluation has been ignored (Zhao and Li, 2015). As interest in environmental and social issues increases, measuring sustainability performance and integrating it into management systems has increased its importance (Hansen and Schalteggar, 2016). The concept of SBSC is derived from traditional BSC, which combines the four perspectives of BSC with sustainability perspectives to explicitly capture environmental, social, or ethical concerns and to include sustainability-related goals and performance measurements (Mio et al., 2022). SBSC is an effective tool for elaborating and designing environmental and social strategies, as well as for assessing the fulfillment of objectives and disclosing corporate sustainability plans (Fernández-González et al., 2023).

Many of the environmental and social issues consist of non-financial indicators. The results of the company's environmental and social activities reveal themselves in the long term. It becomes possible with SBSC to explain the cause-effect relationship between financial indicators that appear in the short term and the results of sustainability activities that occur in the long term (Mio et al., 2022).

Different methods have been suggested by different researchers regarding the integration of the concept of sustainability into BSC (Al-Mawali, 2023). Figge et al. (2002), who first introduced the concept of SBSC to the literature, mentioned three different methods for integrating sustainability into BSC. The first method is to integrate environmental and social issues into the existing four perspectives of the BSC. The second method is to add a fifth perspective to the BSC that includes environmental and social issues. The third method is to create a BSC that is completely customized for environmental and social issues (Figge et al., 2002). Eifert and Julmi (2022), briefly defined these three methods as integrative SBSC, extended SBSC, and derived SBSC. In the literature, there are different opinions about which of the SBSC architectures is better (Al-Mawali, 2023). There is no consensus on which architecture is superior to the other (Eifert and Julmi, 2022). Companies choose the SBSC architecture that best meets their challenges, stakeholder pressures, and needs. To select the most appropriate SBSC architecture, the link between environmental and social issues and strategy should be identified, and the relationship between financial and non-financial indicators should be explained (Eifert and Julmi, 2022). The strategic importance of environmental or social elements is particularly high in sectors that are environmentally sensitive or highly socially exposed (Tsalis et al., 2013). In this paper, the extended SBSC approach was adopted with the idea that adding sustainability as a separate perspective ensures that management and employees pay sufficient attention to sustainability's environmental and social perspective.

One of the multidimensional performance evaluation methods, BSC, inherently involves the consideration of multiple criteria. Due to its inclusion of numerous criteria, the BSC can be regarded as a MCDM problem (Wu et al., 2009). MCDM is a discipline that covers a set of methods used to solve a decision-making problem by considering more than one criterion and helps decision-makers choose between alternatives by considering different criteria (Tsai et al., 2009). AHP (Analytic Hierarchy Process) is a popular MCDM method developed by Saaty (1980), to solve complex decision-making problems. By creating pairwise comparison matrices among alternatives or criteria based on decision-makers' opinions, AHP is employed to determine priorities (Wu et al., 2009). Furthermore, the fact that the hierarchical structure of the BSC is similar to the AHP structure makes it easier for the two methods to be used together (Yüksel and Dağdeviren, 2010).

Although MCDM is a frequently preferred solution method for solving decision problems, the fact that people's decisions in real life are qualitative and cannot be precisely defined makes it challenging to measure these decisions clearly. Fuzzy sets were proposed by Zadeh (1965) as a means to overcome this difficulty. Using fuzzy sets, uncertain or imprecise judgments can be mathematically expressed (Tseng, 2010). Although the AHP method, like other MCDM methods, takes into account the evaluations of decision makers, sometimes it cannot fully reflect people's way of thinking. Using the AHP method with fuzzy sets can eliminate this problem and increase the reliability of decision-making (Zhang et al., 2018). For this reason, the AHP method is often used with fuzzy sets.

Following the proposal of fuzzy sets, various extensions of fuzzy sets have been proposed by different researchers. Intuitionistic fuzzy sets (IFS) proposed by Atanassov (1986) are one of the frequently used extensions of fuzzy sets. Picture fuzzy (PF) fuzzy sets were proposed by Cuong and Kreinovich (2013) as an extension of intuitionistic fuzzy sets. PFSs are more flexible than IFSs in managing the lack of knowledge and uncertainty prevalent in real-world problems (Kaya, 2023). As new fuzzy set extensions are developed, their use with MCDM methods is becoming more common. One of these approaches is the PF-AHP proposed by Kutlu Gündoğdu et al. (2021).

There are a limited number of studies in the SBSC literature where MCDM methods are used together with fuzzy sets. In these studies, F-AHP (Hsu et al., 2017; Raut et al., 2017; Singh et al., 2018) and Fuzzy DEMATEL (Tsai et al., 2020) methods were used. There is a gap in the literature regarding the use of fuzzy MCDM methods with SBSC. To the best of the authors' knowledge, the use of not only SBSC but also BSC together with the PF-AHP method is not available in the literature. The current study aims to fill this gap by showing that the PF-AHP method can be used together with SBSC. Additionally, a modified version of the PF-AHP method is proposed, which is thought to provide ease of calculation when used with BSC.

SBSC has been developed to support corporate sustainability efforts, but there is no clear view on how to create SBSC and how it can be successful (Jassem et al., 2018). Researchers have proposed different formulations of SBSC steps (Figge et al., 2002; Schaltegger and Wagner, 2006; Falle et al., 2016; Eifert and Julmi, 2022). Falle et al. (2016) proposed a methodology that includes the steps of analyzing strategies, identifying environmental and social exposures, establishing SBSC by setting strategic objectives, and strategy mapping. However, these proposed methods alone are insufficient to quantify a company's performance. Moreover, while financial indicators are easier to quantify, indicators related to sustainability may be more difficult to quantify (Huang et al., 2014). Although there are references in the literature to certain aspects of the implementation process of SBSC, there is a lack of holistic approaches to the successful formulation and implementation of SBSC (Tsalis et al., 2013). Chen et al. (2022) state that the SBSC architecture and the adopted criteria may not be appropriate in all cases and caution should be exercised regarding the applicability of the results in other sectors. Falle et al. (2016) state that it can be investigated how

SBSC is implemented in SMEs of different sizes and in different sectors and how it may need to be adapted to accommodate this. SBSC has various applications in different sectors such as the semiconductor manufacturing sector (Hsu et al., 2011), oil processing sector (Rabbani et al., 2014), finance sector (Pérez et al., 2017), aviation sector (Lu et al., 2018), etc. However, it has no application in an SME in the glass processing sector. Based on the above-mentioned discussion, it can be seen that there are few studies in the literature on what perspectives, strategies and Key Performance Indicators (KPIs) SMEs in different sectors should use to manage their sustainability performance and how all these can be implemented. The approach proposed in the current study contributes to filling this gap by showing the application stages in an SME operating in the glass manufacturing sector.

The main contributions of the paper can be summarized as follows: (i) A new approach consisting of the integration of SBSC, PF-AHP and, OMAX methods is proposed to assist companies in the implementation of a sustainable strategy. The proposed approach has been applied in an SME operating in the glass processing company and its applicability has been proven. (ii) To the best of the authors' knowledge, the use of BSC together with the PF-AHP method is not available in the literature. We propose a modified version of the PF-AHP method to facilitate the more straightforward calculation of perspectives, strategic objectives, and KPIs weights within the SBSC. (iii) In order to evaluate the fulfillment of company targets, the OMAX method was applied and the results were discussed.

The rest of the paper is organized as follows: The literature on applications in which BSC and MCDM methods are used together is reviewed in Chapter 2. The basic concepts for PFS, PF-AHP, and OMAX methods are given in Chapter 3. A case study in which the proposed methodology is explained step by step and the results are interpreted is given in Chapter 4. In Chapter 5, the similarities and differences of the study results with studies in the literature are discussed. The similarities and differences of the study results with studies in the literature are discussed in Chapter 5. The conclusion and suggestions for further work are given in the last chapter.

2. Literature review

In this section, the studies in the SBSC literature are divided into two according to whether they are used with MCDM methods or not and examined under separate subheadings. The literature on the criteria used in SBSC is mentioned in the definition of criteria section (Section 4.1) in the application section.

2.1. SBSC

The issue of sustainability is increasing its importance among business stakeholders (Tsalis et al., 2013). Therefore, companies need an effective tool to achieve sustainability goals and measure sustainability performance (Zhao and Li, 2015; Al-Mawali, 2023).

Epstein and Wisner (2001) mentioned that sustainability could be added as a fifth perspective to BSC. Figge et al. (2002) have formulated the SBSC processes and steps and proposed a framework. Möller and Schaltegger (2005) discussed the relationship between SBSC and eco-efficiency analysis. Eco-efficiency analysis is not only a data source for SBSC but also provides a link between environmental management systems and BSCs. Schaltegger and Wagner (2006) proposed some guidelines for the application of SBSC and applied them for Hamburg Airport. Dias-Sardinha and Reijnders (2005) considered the BSC approach to measuring environmental and social performance. They aimed to measure the environmental and social performance of 13 large firms in Portugal by proposing a thematic BSC that includes environmental and social factors instead of the traditional BSC. They questioned the relationship between this thematic BSC and their traditional strategic objectives. They mentioned that a thematic BSC created according to the sectors in which companies operate could be useful. Dias-Sardinha et al. (2007) proposed an SBSC with four different perspectives for measuring environmental performance instead of adding new perspectives to the traditional BSC. They defined these perspectives as triple bottom line, stakeholders, process/products, learning and development and applied them to three large companies. It was concluded that financial success is more important than sustainability in the companies participating in the study, but the participants also stated that adequate management of environmental and social issues contributes to the developing business strategy of the companies. Hubbard (2009) explained the 25-year evolution of performance measurement and then considered the transition to a broader stakeholder perspective in recent times, particularly concerning sustainability performance. Finally, it investigated how organizations measure sustainability performance in practice. He mentioned that currently, sustainability performance is reported separately and this is a step backward for companies using an integrated system such as BSC.

Sardinha et al. (2011), inspired by the SBSC structure, made a corporate social responsibility comparison in 23 real estate companies. Nikolaou and Tsalis (2013) aimed to develop a new SBSC framework by extracting data from corporate sustainability reports and utilizing Global Reporting Initiative (GRI) indicators and benchmarking techniques to measure corporate sustainability performance. Tsalis et al. (2013) proposed a framework based on SWOT analysis in order to increase awareness about the adoption and implementation of SBSC in SMEs. Kang et al. (2015) used SBSC to measure the contribution of corporate social responsibility in family-owned hotels. The opinions of three key hotel stakeholders - customers, managers, and employees - were gathered. The results demonstrate the significant impact of corporate social responsibility on BSC objectives. Agrawal et al. (2016) employed graph theory and SBSC to address the problem of reverse logistics provider selection. Falle et al. (2016) conducted a case study on sustainability management in SMEs (small and medium-sized enterprises) using the SBSC approach. Hansen and Schaltegger (2016) reviewed 69 articles on SBSC in the literature and aimed to reveal the SBSC architecture. While most of the studies integrated both environmental and social indicators into the BSC, some of them only addressed the environmental or social perspective. They concluded that the debate on SBSC is still ongoing, and there are very few applied studies. Jasiulewicz-Kaczmarek and Zywica (2018) implemented SBSC in an enterprise to evaluate the sustainability of maintenance activities. Araújo et al. (2020) integrated sustainability as the fifth perspective of the BSC and applied it to an agricultural company. Mio et al. (2022) analyzed 65 publications on SBSC between 2000 and 2020. They discovered that 47.7% of these publications were case studies, while 30.8% were applied in production enterprises.

2.2. SBSC and MCDM

Due to its incorporation of numerous criteria and the need to analyze the relationships among them, the SBSC is often applied in conjunction with MCDM methods in the literature. Studies using SBSC and different MCDM methods are available in the literature, albeit in limited numbers. Tsai et al. (2009) applied the SBSC-based DEMATEL method for the selection of socially responsible investments. Hsu et al. (2011) proposed an SBSC framework to assess the sustainable performance of the semiconductor industry. They determined sustainability performance criteria through expert opinions and the F-DELPHI method and then weighted them using ANP. Rabbani et al. (2014) developed a novel approach based on SBSC and MCDM approach to evaluate the sustainability performance of oil processing firms. They employed ANP for weighting the factors and the F-COPRAS method to prioritize alternatives. Zhao and Li (2015) first determined the evaluation criteria to be used in SBSC with FDM (fuzzy Delphi method) and calculated the criteria weights with ANP approach. Then, the performance of thermal energy enterprises was evaluated using F-TOPSIS. Lu et al. (2016) utilized a DEMATEL-based ANP method to identify interrelations among criteria and aimed to devise sustainable improvement strategies using the VIKOR method for TFT-LCD manufacturing companies' sustainable competitive advantages. Medel-González et al. (2016) proposed and implemented a model in which they integrated SBSC, AHP, and Matrix of Sustainable Strategic Alignment methods for measuring corporate sustainability performance. Lin et al. (2016) integrated a modified BSC based on Fuzzy Delphi and sustainability to compare the sustainable development competencies required by future technological and vocational higher education. Hsu et al. (2017) used quality function deployment (QFD), Delphi method, fuzzy extent AHP (FEAHP), and TOPSIS methods combined with fuzzy approaches in their study to prioritize performance factors to improve the sustainability of manufacturing SMEs. Raut et al. (2017) aimed to evaluate sustainability practices in banking services using a multi-stage fuzzy SBSC model that integrated F-AHP and F-TOPSIS. Deng et al. (2018) integrated DEMATEL, ANP and VIKOR methods to measure the sustainability performance of chartered public accountant companies. Duman et al. (2018) proposed an approach that integrates DEMATEL, ANP, and SBSC methods for performance evaluation by mentioning the necessity of integrating increasing social and environmental awareness and accompanying legislation into performance evaluation. To demonstrate the functionality of the approach, they conducted a case study in a US-based food franchise business.

Lu et al. (2018) also used the same integrated method to measure the sustainable development performance of airlines. Singh et al. (2018) proposed an integrated approach using F-AHP and FIS (Fuzzy Inference System) to measure the sustainability performance of SMEs. Tsai et al. (2020) aimed to evaluate integrated solid waste management performance with SBSC, Fuzzy Delphi, and Fuzzy DEMATEL methods. Chen et al. (2022) made an SBSC application based on fuzzy Delphi, KANO, and TRIZ methods to determine sustainability performance in the information services sector. Al-Mawali (2023) aimed to create a strategy map for SBSC by determining the relationships between perspectives and KPIs with DEMATEL.

3. Methodology

In this paper, an integrated approach consisting of the SBSC, PF-AHP, and OMAX methods summarized in Fig. 1 Is proposed to meet the sustainability management needs of companies. In the proposed approach, firstly, an extended SBSC is created in which sustainability is added as a separate perspective. Then, the weights of perspectives, objectives, and KPIs are calculated by the PF-AHP method. Finally, the company's performance score is determined using the OMAX method.

In the subsequent sections of this chapter, firstly, the development of fuzzy sets in general and picture fuzzy sets are discussed. Subsequently, the PF-AHP method, which results from integrating picture fuzzy sets with the AHP method, along with its procedural steps, is elucidated.

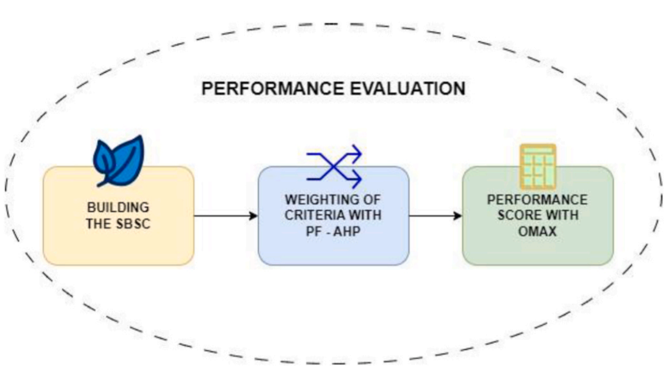

Fig. 1. Steps of the recommended approach.

Table 1
Linguistic terms and Saaty's scale for pairwise comparisons.

Linguistic terms	PFNs (μ, I, v)	Scale
Very High Importance (VHI)	(0.90,0.00,0.05)	7
High Importance (HI)	(0.75,0.05,0.10)	5
Slightly More Importance (SMI)	(0.60,0.00,0.30)	3
Equally Importance (EI)	(0.50,0.10,0.40)	1
Slightly Low Importance (SLI)	(0.30,0.00,0.60)	1/3
Low Importance (LI)	(0.25,0.05,0.60)	1/5
Very Low Importance (VLI)	(0.10,0.00,0.85)	1/7

3.1. Basic concepts of picture fuzzy sets

Fuzzy sets were first proposed by Zadeh in 1965. In classical logic, an object is defined as belonging or not belonging to a set. However, real-world objects often do not have certain membership criteria. Fuzzy sets are used to deal with this situation (Zadeh, 1965). Numerous extensions have been developed and continue to evolve after fuzzy sets were proposed. One of the extensions of classical fuzzy sets, known as type-2 fuzzy sets, was developed by Zadeh (1975). Another popular extension of fuzzy sets, called intuitionistic fuzzy sets, was proposed by Atanassov (1986). Yager (2013) defined the second type of Atanassov's intuitionistic fuzzy sets as Pythagorean fuzzy sets. Neutrophic fuzzy sets presented by Smarandache (1999) represent another extension of intuitionistic fuzzy sets (Kutlu Gündoğdu and Kahraman, 2020). Picture fuzzy sets as an extension of intuitionistic fuzzy sets were proposed by Cuong and Kreinovich (2013).

For voting processes involving multiple responses such as yes, no, abstain, and reject, intuitionistic fuzzy sets may not be sufficient. Furthermore, when an expert seeks opinions from a certain individual about a specific object, that person may express a probability of 0.3 for being correct, 0.4 for being incorrect, and 0.2 for abstaining. In these cases, intuitionistic fuzzy sets cannot solve the problem (Garg, 2017). Picture fuzzy sets have been proposed to solve such problems.

The picture fuzzy set for an element $\tilde{A}_p$ in the set U is given by Eq. (1) (Kutlu Gündoğdu et al., 2021):

$$\tilde{A}_p=\left\{u,\left(\mu_{\tilde{A}_p}(u),I_{\tilde{A}_p}(u),v_{\tilde{A}_p}(u)\right)\middle|u\in U\right\} \tag{1}$$

Eq (2) is valid where $\mu_{\tilde{A}_p}(u):U\rightarrow[0,1]$ $I_{\tilde{A}_p}(u):U\rightarrow[0,1]$ ve $v_{\tilde{A}_p}(u):U\rightarrow[0,1]$:

$$0\le\mu_{\tilde{A}_p}(u)+I_{\tilde{A}_p}(u)+v_{\tilde{A}_p}(u)\le 1 \quad \forall_u \in U \tag{2}$$

For each u, $\mu_{\tilde{A}_p}(u)$ "degree of membership", $v_{\tilde{A}_p}(u)$ "degree of non-membership" and $I_{\tilde{A}_p}(u)$ "degree of indeterminacy". $X_{\tilde{A}_p=}\ 1-(\mu_{\tilde{A}_p}(u)+I_{\tilde{A}_p}(u)+v_{\tilde{A}_p}(u))$ is refusal degree (Kutlu Gündoğdu et al., 2021). For an $\tilde{A}_p$, $\tilde{A}_p=\langle\mu_{\tilde{A}_p},I_{\tilde{A}_p},v_{\tilde{A}_p}\rangle$ is called picture fuzzy (PF) value or picture fuzzy number (PFN). If $\mu_{\tilde{A}_p}(u)=0$ then PFN become intuitionistic fuzzy number, if $I_{\tilde{A}_p}=v_{\tilde{A}_p}=0$ then PFN become fuzzy number (Garg, 2017).

The basic operators for picture fuzzy sets are given by Eqs. (3)–(6) (Kutlu Gündoğdu et al., 2021):

$$\tilde{A}_p\oplus\tilde{B}_p=\left\{\mu_{\tilde{A}_p}+\mu_{\tilde{B}_p}-\mu_{\tilde{A}_p}\mu_{\tilde{B}_p},I_{\tilde{A}_p}I_{\tilde{B}_p},v_{\tilde{A}_p}v_{\tilde{B}_p}\right\} \tag{3}$$

$$\tilde{A}_p\otimes\tilde{B}_p=\left\{\mu_{\tilde{A}_p}\mu_{\tilde{B}_p},I_{\tilde{A}_p}I_{\tilde{B}_p},v_{\tilde{A}_p}+v_{\tilde{B}_p}-v_{\tilde{A}_p}v_{\tilde{B}_p}\right\} \tag{4}$$

$$\lambda.\tilde{A}_p=\left\{\left(1-\left(1-\mu_{\tilde{A}_p}\right)^{\lambda}\right),I_{\tilde{A}_p}^{\lambda}v_{\tilde{A}_p}^{\lambda}\right\}\lambda>0 \tag{5}$$

$$\tilde{A}_p=\left\{\mu_{\tilde{A}_p}^{\lambda},I_{\tilde{A}_p}^{\lambda},\left(1-\left(1-v_{\tilde{A}_p}\right)^{\lambda}\right)\right\}\ \lambda>0 \tag{6}$$

Where $w=(w_1,w_2,\ldots,w_n)$; $w_j\in[0,1]$; $\sum_{j=1}^{n}w_j=1$, the PF geometric

Fig. 2. The structure of SBSC.

average operator (PFWG) is defined as Eq (7) and the PF weighted average operator (PFWA)is defined as Eq (8) (Kutlu Gündoğdu et al., 2021):

$$PFWG_w\left(\tilde{A}_{1,\dots,}\tilde{A}_n\right)=\left\{\prod_{j=1}^{n}\mu_{\tilde{A}_j}^{w_j},\prod_{j=1}^{n}I_{\tilde{A}_j}^{w_j},1-\prod_{j=1}^{n}\left(1-v_{\tilde{A}_j}\right)^{w_j}\right\} \tag{7}$$

$$PFWA_w\left(\tilde{A}_{1,\dots,}\tilde{A}_n\right)=\left\{1-\prod_{j=1}^{n}\left(1-\mu_{\tilde{A}_j}\right)^{w_j},\prod_{j=1}^{n}I_{\tilde{A}_j}^{w_j},\prod_{j=1}^{n}v_{\tilde{A}_j}^{w_j}\right\} \tag{8}$$

In the final solution of practical applications, it is necessary to rank PFNs, thus PFNs need to be defuzzified (Garg, 2017). The defuzzification operator proposed by Xu et al. (2019) is defined below:

While $\tilde{a}=(\mu,I,v)$ is a PFN then neutral degree (π) is given with Eq. (9):

$$\pi=1-\mu-I-v \tag{9}$$

Distribution of the neutral degree to the positive degree and negative degree given with Eq. (10) and Eq. (11):

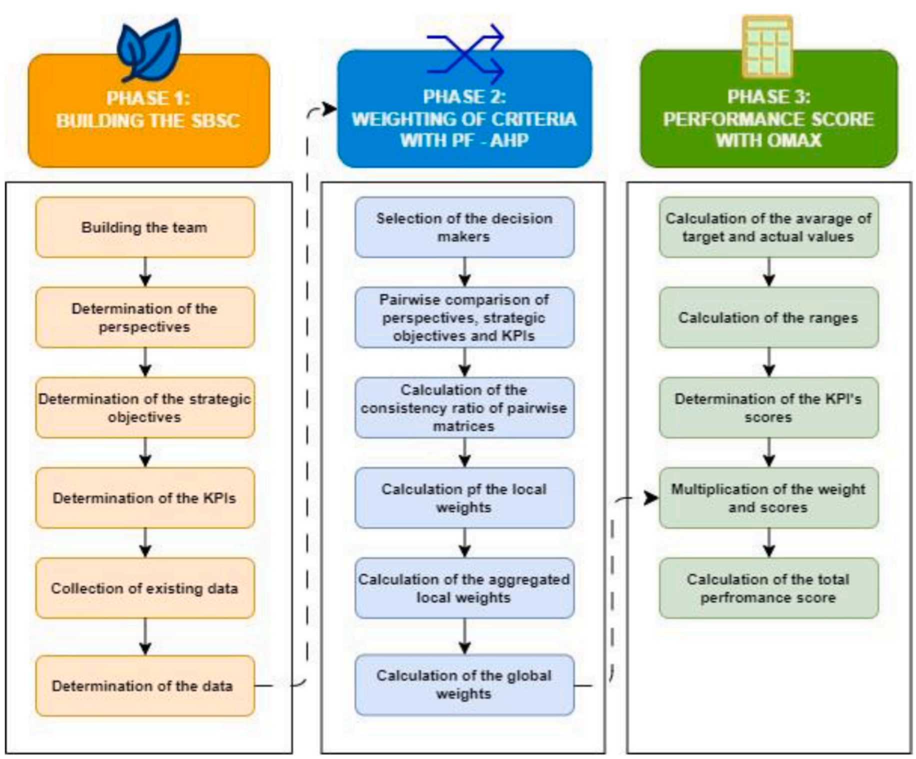

Fig. 3. The phases of application.

Table 2
Perspectives, strategic objectives and KPIs on the SBSC.

Pers.	Strategic Obj.	Reference	KPI	Reference
Financial (F)	Strengthening the Financial Structure (F1)	–	Current Ratio (F11)	–
			Leverage Ratio (F12)	–
	Reducing Costs (F2)	Kaplan and Norton (1996a), Ravi et al. (2005), Wu et al. (2011), Pérez et al. (2017), Singh et al. (2018), Fouladgar et al. (2011), Karahalios (2014), Karahalios et al. (2011)	Electricity Cost (F21)	
			Labor Costs (F22)	Chen et al. (2011)
	Increasing Revenue (F3)	Kaplan and Norton (1996a), Cebeci (2009), Karahalios et al. (2011), Karahalios (2014), Leksono et al. (2019)	Increase in Sales (Revenue Development) (F31)	Kaplan and Norton (1996a), Chen et al. (2011), Tjader et al. (2014), Rabbani et al. (2014), Quezada et al. (2018), Deng et al. (2018), Hubbard (2009)
			Profitability of Sales (F32)	Butler et al. (1997)
			Return on Equity (F33)	–
Customer (C)	Increasing Customer Satisfaction (C1)	Tseng (2010), Leung et al. (2006), Chen et al. (2011), Deng et al. (2018), Wu et al. (2011), Raut et al. (2017), Fouladgar et al. (2011), Singh et al. (2018), Hsu et al. (2011), Leksono et al. (2019), Yüksel and Dağdeviren (2010)	Customer Complaints (C11)	Wu et al. (2009), Cebeci (2009)
			On-Time Delivery Rate (C12)	Kaplan and Norton (1996b), Cebeci (2009)
			Customer Satisfaciton Survey (C13)	Cebeci (2009)
	Ensuring Customer Loyalty (C2)	Kaplan (2001), Wu et al. (2009), Chen et al. (2011), Wu et al. (2011), Cebeci (2009)	Rate of New Customers Rate (C21)	Wu et al. (2009)
	Increasing Customer Acquisition (C3)	Yüksel and Dagdeviren (2010)Yüksel and Dağdeviren (2010)	Number of New Customers (C31)	Quezada et al. (2018), Hubbard (2009)
			Revenue from New Customers (C32)	Chen et al. (2011)
	Increasing Market Share (C4)	Tseng (2010), Wu et al. (2009), Chen et al. (2011)	Increasing Foreign Market Share (C41)	–
Internal Processes (IP)	Increasing Product Quality (IP1)	Tjader et al. (2014), Galankashi et al. (2016), Singh et al. (2018)	Glass Cutting Waste Rate (IP11)	–
			Glass Processing Waste Rate (IP12)	–
			IGU Waste Rate (IP13)	–
			Goods Made Free of Charge under Warranty (IP14)	–
	Ensuring the Efficiency of Production Activities (IP2)	–	Response Speed to Breakdown (IP21)	–
			Repair Time (IP22)	–
	Developing Supplying Activities (IP3)	–	Deadline for Supplying Orders (IP31)	–
			Ratio of Supplier Nonconformities (IP32)	–
Learning and Growth (LG)	Increasing Employee Productivity (LG1)	Chen et al. (2011), Deng et al. (2018), Pérez et al. (2017), Fouladgar et al. (2011)	Revenue per Employee (LG11)	–
			Nonconformity Ratio per Employee (LG12)	–
	Ensuring Employee Permanence (LG2)	Wu et al. (2009), Quezada et al. (2018), Wu et al. (2011)	Employee Turnover (LG21)	Hubbard (2009), Cebeci (2009)
			Rate of Covering Demanded Personnel Employment (LG22)	–
	Providing Employee Satisfaction (LG3)	Leung et al. (2006), Wu et al. (2009), Chen et al. (2011), Tjader et al. (2014), Wu et al. (2011), Hubbard (2009), Cebeci (2009), Galankashi et al. (2016), Modak et al. (2017), Hsu et al. (2011)	Overtime Hours (LG31)	–
			Unused Leave Periods (LG3)	–
Sustainability (S)	Reducing Natural Resource Consumption (S1)	Raut et al. (2017)	Water Consumption (S11)	Hsu et al. (2011)
			Electricity Consumption (S12)	Hsu et al. (2011)
			Natural Gas Consumption (S13)	–
	Enabling Waste Management (S2)	Raut et al. (2017), Quezada et al. (2018)	Amount of Hazardous Waste per Unit (S21)	–
			Amount of Non-hazardous Waste per Unit (S22)	–
	Protecting the Health and Safety of Employees (S3)	Rabbani et al. (2014), Lu et al. (2018), Hsu et al. (2011),Tsai et al. (2009), Quezada et al. (2018)	Number of Occupational Accidents (S31)	Hsu et al. (2011)

$$\mu^{'} = \mu + \frac{I}{2} \quad (10)$$

$$v^{'} = v + \frac{I}{2} \quad (11)$$

The defuzzified value y is calculated by Eq. (12):

$$y = \mu^{'} + \frac{1 + \mu^{'} - v^{'}}{2} \pi \quad (12)$$

3.2. Picture fuzzy AHP

AHP is an MCDM method developed by Saaty (1980) for evaluating main and sub-criteria in a hierarchical structure. In real-world problems with uncertain pairwise comparisons, fuzzy AHP is more suitable and effective than traditional AHP (Lee et al., 2008). Different extensions of fuzzy sets are frequently used in conjunction with AHP. Recently, there have been studies in the literature where PF is integrated with AHP for various applications. Kutlu Gündoğdu et al. (2021) aimed to measure public transportation quality by integrating PF-AHP and the linear assignment method (LAM). Mahmood et al. (2021) developed operators for the interval-valued PF-AHP method. Kim and Van (2021) proposed a new model to address policy evaluation problems under uncertainty by integrating PF sets with the traditional TOPSIS-AHP model. Göçer (2021) utilized interval-valued PF (IVPFS) based AHP and VIKOR methods to determine sustainable supply chain strategies. Ilderomi et al. (2022) used PF-AHP and LAM integrated methods to prioritize flood zones in Iran. Meshram et al. (2022) also prioritized soil erosion basins with the same integrated method. Nguyen et al. (2023) ranked Sad-Kalan sub-basins in terms of flood potential using PF-AHP method, using different MCDM approaches to assess the extent to which the Sad-Kalan basin in Iran participates in floods.

In this paper, some steps of the PF-AHP method developed by Kutlu Gündoğdu et al. (2021), have been modified. In the mentioned study, after decision-makers' evaluations of the main and sub-criteria, the steps are continued using PFNs until the final stage. At the last stage, the PFNs are defuzzified. However, this approach complicates the calculations in cases where there are many sub-criteria and/or multiple levels of sub-criteria in the hierarchical structure. Therefore, in this paper, it is proposed to perform defuzzification after combining decision-maker evaluations and continue the process steps using crisp numbers. The proposed steps of the PF-AHP method are provided below:

Step 1: Pairwise comparison matrices are created for the criteria, and consistency ratios are calculated using the consistency analysis method proposed by Saaty (1980). In the case of evaluating n criteria $C_j = \{C_1, C_2 \ldots, C_n\}$, nxn size A pairwise comparison matrix is constructed with using linguistic terms given in Table 1 (Kutlu Gündoğdu et al., 2021).

Step 2: Local weights ($\widetilde{w}^{local}$) are calculated by using Eq. (8) for assessments for each criterion and sub-criteria taken from the decision-makers (DMs) (Kutlu Gündoğdu et al., 2021).

Step 3: In the decision-making process, there may be multiple DMs. In such cases, the opinions of all DMs are combined using Eq. (8), and the aggregated local weights ($\widetilde{w}^{a-local}$) are calculated. The values of $\widetilde{w}^{a-local}$ are PFNs at this stage.

Step 4: The values of $\widetilde{w}^{a-local}$ are defuzzified using Eqs. (10-13) and the weights of the criteria ($w^{a-local}$) are obtained as crisp numbers.

Step 5: $w^{a-local}$ values are normalized.

Step 6: When there are sub-criteria, the w^{global} value is calculated by multiplying the normalized local weights of the main criteria and the normalized local weights of the sub-criteria.

3.3. OMAX

OMAX was developed by James L. Riggs for productivity analysis (Wibowo and Sholeh, 2015). It is a performance measurement method that evaluates various productivity criteria by weighting them to obtain a total productivity score, provides convenience in terms of applicability (Balkan, 2011).

In the OMAX method, firstly, KPIs and their targets are determined for performance measurement (Balkan, 2011). Possible factors affecting performance with respect to KPIs are defined in a 10-level scale in OMAX (Okfalisa et al., 2018). Performance values corresponding to these levels are determined using interpolation, where levels 1 and 2 are assigned values between 0 and 3, while levels 4 to 9 are assigned values between 3 and 10 (Immawan et al., 2019). Level 0 indicates the worst performance or the farthest distance from the target. Level 3 represents the average achievement in KPI performance, while level 10 indicates the maximum level of success or the closest performance to the target (Immawan et al., 2019; Okfalisa et al., 2018). In the OMAX scale, the level value that corresponds closest to the performance of the relevant KPI is taken as the score for that KPI (Balkan, 2011).

In OMAX, a weight must be determined for each KPI. For this, there are studies conducted in the form of obtaining direct opinions from the relevant people or determining the weight with the AHP method. Multiplication of determined weights and scores gives the performance score of that KPI (Okfalisa et al., 2022).

Table 3
Weights of.

DM	Title	Weight
DM1	Business Manager	0.25
DM2	Factoy Manager	0.25
DM3	Production Manager	0.15
DM4	Assistant Sales Manager	0.20
DM5	Quality Supervisor	0.15

4. Case study

This paper applied the proposed method in a glass processing company operating in Samsun, Turkey for more than 60 years. The study consists of three stages. In the first stage, a team was formed by selecting people from the units performing different company functions for the SBSC project, and this team determined a plan for the project with meetings and training sessions. Following the devised plan, the first step in creating the BSC was determining the perspectives. Due to the increasing importance of sustainability in today's world, sustainability has been determined as the fifth perspective of BSC, and it has been decided to conduct a SBSC study.

Table 4
Pairwise comparison matrix of perspectives according to DM1.

	F	C	IP	LG	S
F	EI	SMI	HI	HI	VHI
C	SLI	EI	HI	VHI	SMI
IP	LI	LI	EI	SMI	EI
LG	LI	VLI	SLI	EI	LI
S	VLI	SLI	EI	HI	EI

Table 5
PFN pairwise comparison matrix of perspectives according to DM1.

	F	C	IP	LG	S
F	(0.50, 0.10, 0.40)	(0.60, 0.00, 0.30)	(0.75, 0.05, 0.10)	(0.75, 0.05, 0.10)	(0.90, 0.00, 0.05)
C	(0.30, 0.00, 0.60)	(0.50, 0.10, 0.40)	(0.75, 0.05, 0.10)	(0.90, 0.00, 0.05)	(0.60, 0.00, 0.30)
IP	(0.25, 0.05, 0.60)	(0.25, 0.05, 0.60)	(0.50, 0.10, 0.40)	(0.60, 0.00, 0.30)	(0.50, 0.10, 0.40)
LG	(0.25, 0.05, 0.60)	(0.10, 0.00, 0.85)	(0.30, 0.00, 0.60)	(0.50, 0.10, 0.40)	(0.25, 0.05, 0.60)
S	(0.10, 0.00, 0.85)	(0.30, 0.00, 0.60)	(0.50, 0.10, 0.40)	(0.75, 0.05, 0.10)	(0.50, 0.10, 0.40)

The traditional BSC consists of financial, customer, internal processes, and learning and growth perspectives. In order to determine the performance of these perspectives, strategic objectives, KPIs, and targets are determined. KPIs are derived from strategic objectives. Therefore, strategic objectives, KPIs and targets are specific to each company. The BSC links strategic objectives to action plans (Tsang, 1998). The inclusion of the sustainability perspective in the BSC gave rise to the concept of SBSC (Figge et al., 2002). The structure of SBSC is presented in Fig. 2.

After determining the perspectives, strategic objectives and KPIs were determined through literature review, brainstorming and meetings. While determining these objectives and factors, care was taken to ensure that the selected indicators reflect the actual performance. Subsequently, historical data for these indicators were collected from relevant units, and the project team determined targets for the upcoming year.

In the second phase of the application, five DMs were selected from the project team to gather their opinions on the weighting of perspectives, strategic objectives, and KPIs in the SBSC. Care was taken to ensure that the chosen DMs would provide realistic and balanced perspectives for the entire company. The weights assigned by the DMs were determined in collaboration with the project team. The DMs were asked to make pairwise comparisons for perspectives, strategic objectives, and KPIs, and the steps of the developed PF-AHP method were applied to calculate the weights of perspectives, objectives, and KPIs. In the third phase, a general performance score was calculated for the company. The actual values for the set targets were collected from relevant units, and the performance score was calculated using the steps of the OMAX method. The phases of the conducted application are illustrated in Fig. 3.

their positions and experiences within the company. The weights of the DMs to be used in the calculations were determined as in Table 3.

Pairwise comparison matrices were created by asking DMs to evaluate perspectives, strategic objectives and KPIs separately. The pairwise comparison matrices were evaluated according to the consistency analysis method proposed by Saaty (1980). Since all consistency values were below 0.1, it was assumed that the evaluations provided by the DMs were consistent.

The linguistic terms were converted into PFNs in the pairwise comparison matrices according to Table 2. Firstly, local weights ($\widetilde{w}^{local}$) of perspectives, strategic objectives, and KPIs were calculated for each DM using Eq. (8). Because the calculations are long, the steps of the method are explained through DM1's evaluations of perspectives. The pairwise comparison matrix for the perspectives, created with the opinions from DM1, is shown in Table 4, and the converted form of this matrix in PFNs is presented in Table 5.

The calculation of the local weights ($\widetilde{w}^{local}$) for the comparison matrix showing the financial perspective against the other perspectives for DM1 is as follows using Eq. (8). Since the matrix is five dimensional, $w_j = \frac{1}{5} = 0,2$ was calculated. Similarly, the local weights were individually calculated for all DMs. Calculated local weight values of perspectives for each DM are given in Table 6.

$$PFWG_{KV1} = \begin{bmatrix} \left(0.50^{0.20} \text{ x } 0.60^{0.20} \text{ x } 0.75^{0.20} \text{ x } 0.75^{0.20} \text{ x } 0.90^{0.20}\right), \\ \left(0.10^{0.20} \text{ x } 0.00^{0.20} \text{ x } 0.05^{0.20} \text{ x } 0.05^{0.20} \text{ x } 0.00^{0.20}\right), \\ \left(1-\left((1-0.40)^{0.20} \text{ x } (1-0.30)^{0.20} \text{ x } (1-0.10)^{0.20} \text{ x } (1-0.10)^{0.20} \text{ x } (1-0.05)^{0.20}\right)\right) \end{bmatrix} = (0.6860, 0.0000, 0.2022)$$

At this stage, the calculated local weights for each DM, consisting of PFNs, were combined using Eq. (8) to obtain the aggregated local weights ($\widetilde{w}^{a-local}$). Here, w_j values are the weights of the DMs given in Table 3. An example calculation for the financial perspective is provided below:

$$PFWG_{F} = \begin{bmatrix} \left(0.6860^{0.25} \text{ x } 0.5578^{0.25} \text{ x } 0.5078^{0.15} \text{ x } 0.6325^{0.20} \text{ x } 0.6614^{0.15}\right), \\ \left(0.0000^{0.25} \text{ x } 0.0000^{0.25} \text{ x } 0.0000^{0.15} \text{ x } 0.0000^{0.20} \text{ x } 0.0000^{0.15}\right), \\ \left(1-\left((1-0.2022)^{0.25} \text{ x } (1-0.3216)^{0.25} \text{ x } (1-0.3812)^{0.15} \text{ x } (1-0.2495)^{0.20} \text{ x } (1-0.2108)^{0.15}\right)\right) \end{bmatrix} = (0.6093, 0.0000, 0.2782)$$

4.1. Definition of criteria

In order to create SBSC, the literature on BSC and SBSC was reviewed, and the views of the project team and managers were obtained to determine the strategic objectives, KPIs, and indicators needed for the company's performance measurement. The SBSC created for the company includes five perspectives, 16 strategic objectives, and 34 KPIs. Table 2 gives the perspectives, strategic objectives, and KPIs in the SBSC created for the company.

4.2. Weighting of criteria

PF-AHP method was used to determine the weights to be used in the performance score calculation. By taking the opinions of five DMs selected from within the company, pairwise comparison matrices were created for size, strategic purpose and critical success factors and calculations were performed. As the contribution of each DM's perspective to the solution may vary at different levels in decision-making problems. Different weights were assigned to the DMs, taking into consideration

The calculated aggregated local weights ($\widetilde{w}^{a-local}$) were defuzzified using Eqs. 9–12 and these defuzzified values were then normalized to obtain the values of $w^{a-local}$. An example calculation for the financial perspective is provided below:

$$\widetilde{w}^{a-local} = (0.6093, 0.0000, 0.2782)$$

$$\pi = 1 - 0,6093 - 0,2782 = 0,1125$$

$$\mu' = 0,6093 + \frac{0,0000}{2} = 0,6093$$

$$v' = 0,2782 + \frac{0,0000}{2} = 0,2782$$

$$w^{a-local} = 0,6093 + \frac{1 + 0,6093 - 0,2782}{2} 0,1125 = 0,6842$$

The local score values for the perspectives are obtained by dividing the defuzzified value of each criterion by the total value of the criteria.

Table 6
Calculated local weights ($\tilde{w}^{local}$) of perspectives.

	DM1	DM2	DM3	DM4	DM5
F	(0.6860,0.0000,0.2022)	(0.5578,0.0000,0.3419)	(0.5078,0.0000,0.3812)	(0.6325,0.0000,0.2495)	(0.6614,0.0000,0.2108)
C	(0.5711,0.0000,0.3216)	(0.5833,0.0000,0.3079)	(0.6099,0.0000,0.2723)	(0.5078,0.0000,0.3812)	(0.5506,0.0000,0.3289)
IP	(0.3930,0.0000,0.4739)	(0.3710,0.0000,0.4898)	(0.5624,0.0000,0.3289)	(0.4896,0.0000,0.4000)	(0.3930,0.0000,0.4739)
LG	(0.2480,0.0000,0.6435)	(0.4227,0.0000,0.4574)	(0.3680,0.0000,0.5148)	(0.4420,0.0000,0.4407)	(0.3930,0.0000,0.4739)
S	(0.3548,0.0000,0.5453)	(0.2978,0.0000,0.5662)	(0.2978,0.0000,0.5662)	(0.2391,0.0000,0.6435)	(0.3204,0.0000,05662)

This normalization process ensures that the weights are normalized, and their total values equal to 1. The local score value for each sub-criteria is then multiplied by the local score value of the main criteria, and the global weights (w^{global}) are calculated. These global weights calculated are the final weights of the criteria and are given in Table 7.

As a result of the calculations, it is seen that the weight of the financial (F) perspective is 0.267, the weight of the weight of the customer (C) perspective is 0.247, the weight of the internal processes (IP) perspective is 0.191, the weight of the learning and development perspective (LG) is 0.161, and the weight of the sustainability (S) perspective is 0.134. The weights of the strategic objectives and KPIs are appropriately ranked in proportion to the weights of the perspectives they are associated with. Among the strategic objectives under the financial perspective, two out of three ranks among the top two positions among all strategic objectives, while the strategic objectives under the sustainability perspective are positioned at the lowest ranks.

4.3. Calculation of performance rating

The indicators for KPIs were derived from the literature and the company's knowledge base. Of the 34 identified KPIs, 14 were determined as maximization and 20 as minimization criteria. Having a KPI as a maximization criterion indicates that the company aims for an increase in that value, while having it as a minimization criterion indicates the company's desire for a decrease in that value. Indicators of KPIs and max.-min. Conditions are given in Table 8.

The overall performance score calculated for the company is 6.14 out of 10 (see Table 9). This value shows the level of reaching the indicators determined by the company for KPIs. In this case, the level of achievement of the set KPIs can be considered as 60%. Out of the 34 KPIs, there are 10 indicators with a performance score of 0, indicating that the desired performance was not achieved for these 10 indicators. When looking at the weighting of the KPIs, it is observed that 6 out of these 10 unsuccessful indicators are among the top ten factors in terms of weight. The total weight of the unsuccessful 10 factors is 0.37. Therefore, this situation has had a negative impact on the overall performance score. Conducting a thorough investigation into the fully achieved, over-achieved, and unsuccessful targets and identifying the reasons behind the unachieved targets will be crucial for improving the company's

Table 7
Weights of the perspectives, strategic objectives and KPIs.

PERS.	w^{global}	STR. OBJ.	$w^{a-local}$	w^{global}	KPI	$w^{a-local}$	w^{global}
F	0.267	**F1**	0.3148	0.0840	**F11**	0.5494	0.0462
					F12	0.4506	0.0379
		F2	0.2603	0.0695	**F21**	0.6487	0.0451
					F22	0.3513	0.0244
		F3	0.4249	0.1135	**F31**	0.3352	0.0380
					F32	0.3784	0.0429
					F22	0.2865	0.0325
C	0.247	**C1**	0.2450	0.0605	**C11**	0.3229	0.0195
					C12	0.3428	0.0207
					C13	0.3344	0.0202
		C2	0.2108	0.0521	**C21**	1.0000	0.0521
		C3	0.2273	0.0561	**C31**	0.4105	0.0230
					C32	0.5895	0.0331
		C4	0.3169	0.0783	**C41**	1.0000	0.0783
IP	0.191	**IP1**	0.3310	0.0632	**IP11**	0.1900	0.0120
					IP12	0.2376	0.0150
					IP13	0.2497	0.0158
					IP14	0.3226	0.0204
		IP2	0.3038	0.0580	**IP21**	0.5299	0.0308
					IP22	0.4701	0.0273
		IP3	0.3652	0.0698	**IP31**	0.4034	0.0281
					IP32	0.5966	0.0416
LG	0.161	**LG1**	0.4678	0.0753	**LG11**	0.5804	0.0437
					LG12	0.4196	0.0316
		LG2	0.2851	0.0459	**LG21**	0.5804	0.0266
					LG22	0.4196	0.0193
		LG3	0.2471	0.0398	**LG31**	0.4850	0.0193
					LG32	0.5150	0.0205
S	0.134	**S1**	0.2965	0.0397	**S11**	0.3355	0.0133
					S12	0.4500	0.0179
					S13	0.2145	0.0085
		S2	0.2661	0.0357	**S21**	0.5158	0.0184
					S22	0.4842	0.0173
		S3	0.4374	0.0586	**S31**	1.0000	0.0586

Table 8
The KPIs and their corresponding maximization or minimization statuses.

KPI	INDICATOR	MIN/ MAX
F11	Current Assets/Current Liabilities	Max.
F12	Total Debt/Total Assets	Min.
F21	Electricity Cost/Total Costs	Min.
F22	Labor Cost/Total Costs	Min.
F31	New Period Sales - Previous Period Sales/Previous Period Sales (USD)	Max.
F32	Period Net Profit or Loss/Net Sales	Max.
F22	Period Net Profit or Loss/Equity	Max.
C11	Annual Number of Complaints/Annual Total Number of Customers	Min.
C12	Number of Orders Delivered on Time/Total Number of Orders	Max.
C13	Customer Satisfaction Survey Results	Max.
C21	Annual Number of New Customers/Total Number of Customers	Min.
C31	Annual Number of New Customers	Max.
C32	Revenue from New Customers/Total Revenues	Max.
C41	Annual Exports/Total Sales	Max.
IP11	Rework Quantity/Production Quantity	Min.
IP12	Rework Quantity/Production Quantity	Min.
IP13	Rework Quantity/Production Quantity	Min.
IP14	Sales Value of Goods Made Free of Charge under Warranty/ Total Sales	Min.
IP21	Repair Activity Start Date - Report Date Ratio	Max.
IP22	Average Repair Time (hours)	Min.
IP31	Average of Product Arrival Date-Purchase Order Date Difference	Min.
IP32	Number of Nonconformity from Suppliers/Total Noncomformities	Min.
LG11	Net Sales/Number of Employees	Min.
LG12	Number of Nonconformities Due to Employee/Total Noncomformities	Min.
LG21	Number of Employees Quit/Number of Employees	Min.
LG22	Number of Hired Employees/Requested Number of Employees	Max.
LG31	Total Overtime Hours/Total Number of Employees	Min.
LG32	Total Remaining Leave Days/Total Number of Employees	Min.
S11	Annual Water Consumption (m3)	Min.
S12	Annual Electricity Consumption (kVA)	Min.
S13	Annual Natural Gas Consumption (m3)	Min.
S21	Amount of Hazardous Waste Sent to Disposal/Annual Glass Production	Max.
S22	Amount of Non-Hazardous Waste Sent to Recycling/Annual Glass Production	Max.
S31	Annual Number of Occupational Accidents	Min.

Table 9
Determined achivement score (AS) and performance score (PS).

KPI	Weight	AS	PS	KPI	Weight	AS	PS	KPI	Weight	AS	PS
F11	0.046	10	0.4617	C32	0.033	10	0.3309	LG21	0.027	7	0.1865
F12	0.038	0	0.0000	C41	0.078	10	0.7826	LG22	0.019	10	0.1926
F21	0.045	0	0.0000	IP11	0.012	10	0.1201	LG31	0.019	10	0.1930
F22	0.024	7	0.1709	IP12	0.015	0	0.0000	LG32	0.020	10	0.2049
F31	0.038	0	0.0000	IP13	0.016	0	0.0000	S11	0.013	10	0.1333
F32	0.043	0	0.0000	IP14	0.020	0	0.0000	S12	0.018	10	0.1788
F22	0.033	0	0.0000	IP21	0.031	10	0.3075	S13	0.009	10	0.0852
C11	0.020	10	0.1954	IP22	0.027	10	0.2728	S21	0.018	10	0.1839
C12	0.021	10	0.2075	IP31	0.028	10	0.2814	S22	0.017	10	0.1727
C13	0.020	10	0.2024	IP32	0.042	0	0.0000	S31	0.059	0	0.0000
C21	0.052	10	0.5207	LG11	0.044	10	0.4372				
C31	0.023	0	0.0000	LG12	0.032	10	0.3160				

performance.

5. Discussions of results

In this paper, an integrated approach was proposed to determine the sustainability performance of companies and was applied to a glass processing company. The study's findings can guide for performance evaluation for companies of similar scale to the company where applied.

Evaluating sustainability performance is an important step for a business to reveal its economic, environmental, and social situation (Chen et al., 2022). KPIs and targets that measure sustainability performance should be determined to meet stakeholders' expectations, such as suppliers and customers (Hristov et al., 2019; Al-Mawali, 2023). SBSC effectively explains the balance between sustainability indicators and financial, customer, internal processes, and learning development indicators. In the study, literature, and the knowledge of the employees in the business were used to determine the objectives and KPIs (Duman et al., 2018; Hsu et al., 2011).

In case studies (Tsai et al., 2009; Hsu et al., 2011; Rabbani et al., 2014; Lu et al., 2018; Deng et al., 2018; Duman et al., 2018; Wang et al., 2022; Chen et al., 2022; Al-Mawali, 2023) sustainability performance evaluation has generally been carried out at two levels: perspectives and objectives or just perspectives and KPIs. This study has three levels of SBSC: perspectives, strategic objectives, and KPIs. Therefore, the sensibility in weighting and performance measurement is higher. However, the analysis levels of this study make it difficult to compare the results with other studies. In studies using SBSC to measure sustainability performance, perspectives are also determined in different ways and numbers. Financial/economic, internal processes, customer and learning & growth are the most common perspectives (Rabbani et al., 2014; Zhao and Li, 2015; Agrawal et al., 2016; Duman et al., 2018; Deng et al., 2018; Lu et al., 2018; Araújo et al., 2020; Chen et al., 2022; Al-Mawali, 2023). However, environmental (Rabbani et al., 2014; Zhao and Li, 2015; Agrawal et al., 2016; Lu et al., 2018; Chen et al., 2022), social (Rabbani et al., 2014; Agrawal et al., 2016; Chen et al., 2022) and sustainability (Hsu et al., 2011; Zhao and Li, 2015; Araújo et al., 2020; Al-Mawali, 2023) perspectives are used for measuring sustainability performance. In contrast, some studies examined the relationship between perspectives (Chen et al., 2011; Quezada et al., 2018; Leksono et al., 2019; Acuña-Carvajal et al., 2019; Lin, 2022; Al-Mawali, 2023) some studies measured performance by weighting (Wu et al., 2009; Hsu et al., 2011; Rabbani et al., 2014; Duman et al., 2018; Deng et al., 2018; Lu et al., 2018; Chen et al., 2022). "Customer" perspective was the best according to Wu et al. (2009), which applied to the banking industry; Chen et al. (2022), which applied to IT services; and Deng et al. (2018), which applied to certified public accountant firms. Duman et al. (2018) found the best perspective is "internal processes" applied in the food industry, while Lu et al. (2018) found a "social" perspective at international airports. In this study the weight of the financial (F) perspective was calculated as 0.267, the weight of the customer (C) perspective was 0.247, the weight of the internal processes (IP) perspective was 0.191, the weight of the learning and development (LG) perspective was 0.161, and the weight of the sustainability (S) perspective was calculated as 0.134. It shows that different industries have different evaluations about corporate sustainability (Hsu et al., 2017). When calculating the weights, give the highest weight to the financial perspective and the lowest weight to the sustainability perspective, which shows that the traditional perspective in performance evaluation for a business of this scale has not changed. However, stakeholder pressures on sustainability will become an indispensable key to financial success in the near future. Therefore, awareness-raising activities regarding sustainability should be increased. Although the sustainability perspective has the lowest weight, all indicators determined under the perspective have reached the desired performance level. The level of success in indicators under the financial perspective, with the highest weight, is 30%. It is predicted that business performance will increase to higher levels by changing the perspective on sustainability.

While determining objectives and KPIs, literature is the most important source shown at Table 2. As mentioned before in the literature, there are studies that have objectives, KPIs, or measures only, so we used them directly sometimes and sometimes for inspiration. Today, increasing the use of renewable energy resources and minimizing the use of natural resources is important for individuals and companies (Dincer and Yuksel, 2019). Hsu et al. (2011) used "energy consumption" about this concern, and this study added Annual Water Consumption (S11), Annual Electricity Consumption (S12), and Annual Natural Gas Consumption (S13) to SBSC for this purpose. Hsu et al. (2011) ranked "energy consumption" 13th out of 25 measures, while this study ranked S11 as 32nd, S12 as 28, and S13 as 34th out of 34 KPIs. The main production area of the company where the application is made is glass processing. Glass inherently poses a physical hazard. For this reason, it is important to keep occupational accidents occurring in the enterprise under control. Annual Number of Occupational Accidents (S31) indicator is taken into account in SBSC within the performance in the social perspective of sustainability inspired from Hsu et al. (2011) "health and safety of employee". S31 was ranked as second while inspired study ranked it as 20th out of 25. Hazardous and non-hazardous wastes are inspected to ensure compliance with national environmental legislation. Disposal of hazardous waste produced in the enterprise and recycling of non-hazardous waste minimizes the negative effects of the enterprise on the environment. Amount of Hazardous Waste Sent to Disposal/Annual Glass Production (S21) and Amount of Non-Hazardous Waste Sent to Recycling/Annual Glass Production (S22) indicators were determined for this purpose inspired by Raut et al. (2017) and developed for the company's needs. S11, S12, S13, S21 and S22 indicators were used to explain the environmental perspective of sustainability performance. Since the indicators related to the economic perspective of sustainability are considered in the financial perspective, they are not evaluated under the sustainability perspective. However, the objectives and KPIs related to social and environmental perspectives are open to improvement. Objectives or KPIs such as increasing the use of renewable energy resources and developing social responsibility projects can also be addressed in sustainability perspective. The field of activity and scale of the business to be implemented will shape the sustainability perspective in different directions.

By applying SBSC, companies can integrate sustainability into their strategies. Achieving this successfully provides companies with stakeholder satisfaction and competitive advantage while increasing corporate reputation. Companies may face different challenges to achieving this success. Since the effects of sustainability activities will emerge in the long term, company owners and managers do not want to allocate resources to these activities (Eifert and Julmi, 2022). For this reason, sustainability-related projects may not be preferred because they are long-term and costly. However, while traditional performance indicators such as financial, customer, and internal processes are easier to express quantitatively, sustainability indicators are more difficult to express (Huang et al., 2014). National and international sustainability policies and laws need to be kept up to date. In addition, variability in environmental and social factors such as climate change, natural disasters, poverty, war, and terrorism can also make it difficult to measure sustainability performance (Sharifi and Simangan, 2021). These problems considered, and solutions should be sought when SBSC applications are carried out today and in the future. Adding different objectives and indicators to SBSC, training business managers and employees on the subject, and increasing legal obligations are some of the solutions (Mio et al., 2022).

6. Conclusion

In order to succeed in their competitive environment, companies should embrace strategic management and measure the effectiveness of their management systems. The BSC has emerged as a performance measurement method to assess this success. The traditional BSC consists of four perspectives: financial, customer, internal processes, and learning and growth. With the growing importance of the concept of sustainability, which defines the measurement of environmental and social performance, the sustainability perspective has been added as the fifth perspective to the BSC, giving rise to the concept of SBSC. Since its introduction to the literature, the BSC has maintained its popularity and applied in numerous companies and investigated in various research studies. The multi-criteria nature of the BSC has led researchers to integrate it with MCDM.

In this paper, the modified PF-AHP method was used to weight the criteria in the SBSC. Additionally, the SBSC was combined with the OMAX method to express the performance numerically. Firstly, a team was selected within the company to create the SBSC, and strategic objectives, KPIs and indicators were identified through references from the literature and the company's knowledge base. Existing data was collected for calculating the performance score, and based on this data, targets were established. The weights for SBSC perspectives, objectives, and KPIs were calculated using the PF-AHP method with the input of opinions from five DMs. The obtained weight values were then utilized in the OMAX method to determine the company's performance score.

The number of studies in the literature that explore the integration SBSC with MCDM is limited. Moreover, in these studies, the SBSC framework generally consists of two levels, perspectives and objectives, and only focus on criteria weighting. This study stands apart from other research by conducting criterion weighting at three levels for SBSC, encompassing perspectives, objectives, and KPIs, and by employing a novel method, the PF-AHP, for this weighting process. Additionally, the study goes beyond merely constructing a framework, determining data, or using MCDM methods to establish weights for SBSC, successfully transitioning the performance measurement from qualitative to quantitative perspectives.

In future research, the perspectives and objectives of the SBSC can be modified. Other MCDM methods available in the literature for weighting can be applied. Additionally, apart from the fuzzy set used in this study, other fuzzy set extensions can be proposed. New methods for calculating the performance score can be developed or existing methods from the literature can be utilized.

CRediT authorship contribution statement

Buse Duygu Dağidir: Methodology, Software, Visualization, Writing – review & editing, Writing – original draft. **Barış Özkan:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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