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To diversify or not to diversify: A fuzzy decision-making model for construction companies

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Research Paper

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Diversification is one of the primary strategies adopted by construction companies. This strategy has both advantages and disadvantages. This study develops a fuzzy, multiple-criteria, decision-making model to determine the most appropriate diversification strategy for construction companies. The data required were obtained during face-to-face interviews, and fuzzy state and fuzzy alternative approaches were used. Consequently, the most appropriate diversification strategies for construction companies are highly diverse. Moreover, the most critical company data for monitoring the reasons for diversification, and the most important indicators for observing company data were identified.

Key words:
construction industry, diversification, decision-making, fuzzy states, fuzzy alternatives, strategy

rethodno priopćenje

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Diversificirati ili ne diversificirati: neizrazit model donošenja odluka za građevinske tvrtke

Diversifikacija je jedna od glavnih strategija građevinskih tvrtki. Ona ima i prednosti i nedostatke. U ovome istraživanju razrađen je neizrazit višekriterijski model donošenja odluka kako bi se odredila najprikladnija strategija diversifikacije za građevinske tvrtke. Traženi podaci dobiveni su tijekom intervjua licem u lice, a primijenjeni su pristupi neizrazitih (fuzzy) stanja i alternativa. Prema tome, najprikladnije strategije diversifikacije za građevinske tvrtke vrlo su raznolike. Uz to utvrđeni su ključni podaci poduzeća relevantni za analizu razloga diversifikacije i najvažniji pokazatelji za praćenje poslovnih informacija.

Ključne riječi:
građevinarstvo, diversifikacija, odlučivanje, neizrazita stanja, neizrazite alternative, strategija

1. Introduction

The construction industry exhibits competitive and risky characteristics as new competitors and markets are constantly emerging [1]. The modern portfolio theory describes diversification as a way of reducing risks. However, construction companies choose a diversification strategy (DS) to spread or eliminate risks [2], increase profitability, create regular cash flow, avoid certain customers/markets, benefit from vertical integration [3], expand geographically, and foster market share [4]. However, company performance cannot be guaranteed that it will improve when this strategy is used [5]. Adamu et al. [6] revealed that diversification negatively affects firm performance in terms of return on investment, return on equity (ROE), return on assets (ROA), return on capital employed (ROCE), and profit margin (PM), while Lee et al. [7] highlighted the neutral effects of DSs on construction companies' insolvency. Conversely, Rhodes et al. [8] and Wang et al. [9] presented positive results for diversification using firm performance and total asset growth rate. Previous studies have not reached a consensus on whether diversification has a positive effect on construction companies' performance. Although there have been some negative results, most studies on diversification have identified positive contributions to the performance of construction companies. These considerations underscore the necessity of implementing a systematic and formalised multi-criteria decision-making (MCDM) framework to evaluate the alternatives. In these situations, MCDM methods, which have been proven effective in addressing decision-making challenges, are appropriate tools [53]. Recently, operational research techniques, particularly MCDM tools, have been increasingly used to support decision makers in evaluating alternatives [54]. This framework, applied specifically to the strategic planning process, can facilitate a more rational and data-driven assessment of competing diversification options and their potential outcomes, ultimately contributing to a greater likelihood of successful diversification.

Previous studies and current applications may encourage construction companies to diversify to maintain their financial sustainability. Various indicators have been used to quantify the performance of diversified construction companies, such as ROE, ROA, ROCE, PM [6, 10–14], and entropy [2, 15–17]. These indicators are based on the financial data of companies, which can be doubted because the validity and reliability of the financial data of companies can be seriously questioned. Moreover, previous studies on construction and other industries have not examined the pre-diversification stages of companies based on expert opinions. To address this lacuna in the existing literature, a fuzzy MCDM model was developed. The focus group discussion (FGD) is strategically designed to elicit the most influential criteria pertaining to DS. The model's development benefited from empirical data collected from a cohort of 40 construction professionals operating in the Turkish construction sector. These individuals held senior management positions in large construction companies, ensuring a high level of domain expertise relevant to the research objectives. A fuzzy Bayesian approach was then adopted to select a compromise diversification alternative for construction companies. The fuzzy states and fuzzy actions (FUSFA) method was used to calculate the expected utility values of fuzzy alternatives for fuzzy states, depending on the fuzzy criteria. Although a considerable body of research addresses DS within the construction industry (see Table 1), a literature review reveals a notable absence of studies that explicitly develop and apply an MCDM model at the corporate level to guide diversification decisions. Many existing studies primarily analyse the outcomes of DS by examining the relationship between diversification and firm performance indicators such as profitability and risk. However, these studies do not typically offer prescriptive models to assist companies in making informed diversification decisions. Although Ravanshadnia et al. [27] explored a related decision-making process, their investigation focused on leveraging the risk-spreading effects of diversification, specifically focussing at the project level rather than at the broader corporate strategic level examined in this study.

This study aims to contribute to the knowledge on construction management by emphasising the most critical factors for DS and helping decision-makers during the pre-diversification process. By developing an MCDM model, senior managers in construction companies can conduct DS decision-making more efficiently and estimate the possible results of diversification.

2. Literature review

There is a vast body of literature on diversification, especially in finance, portfolio management, the construction industry, and agricultural studies. Most of these studies highlight the benefits of diversified products for maintaining successful business operations. From the perspective of the construction industry, previous studies have typically analysed the performances of diversified companies (Table 1). In Table 1, the "Result' column categorises previous study findings as "positive', "neutral', or "negative'. A "positive' result signifies that the study identified a significant and beneficial relationship between diversification and the examined outcome measure(s), such as profitability, firm value, or risk reduction, typically implying superior performance by diversified construction companies compared with their less-diversified counterparts with respect to that specific measure. Conversely, a "neutral' result indicates the absence of a significant relationship between diversification and the assessed outcome measure(s), suggesting that diversification exerted neither a positive nor a negative influence on the performance of construction companies in relation to that measure. Finally, a "negative' result denotes the identification of a significant and detrimental relationship between diversification and the outcome measure(s) under consideration, typically implying that diversified construction companies performed worse than less diversified companies regarding the specified measure.

Table 1. Previous studies on diversification of construction companies

Reference	Approach	Source of data	Method	Result
Tan [18]	Risk reduction	Financial statistics	AIMA	Neutral
Akintoye and Skitmore [19]	Profitability enhancement	Financial statistics	Profit percentage of turnover	Positive
Cho [20]	Application status	Financial statistics	Four-cell matrix	Positive
Cheah et al. [21]	Firm performance	Financial statistics	Analytical template	Neutral
Choi and Russell [4]	Firm performance	Financial statistics	Entropy	Neutral
Cuervo and Pheng [22]	Internalisation	QS	Mean importance rating	Positive
Yee and Cheah [23]	Risk reduction	Financial statistics	Fundamental analysis	Positive
Yee and Cheah [24]	Firm performance	Financial statistics	Fundamental analysis	Positive
Cheah et al. [25]	Competitive advantage	QS	Statistical analysis	Positive
Ibrahim and Kaka [10]	Firm performance	Financial statistics	ROE, ROA, ROCE, PM	Negativan
Wong et al. [26]	Sustainable development	QS	Fox's analytical framework	Positive
Ravanshadnia et al. [27]	Portfolio effect	QS	AHP, SAW	Positive
Kim and Reinschmidt [15]	Firm performance	ENR reports	Entropy	Neutral
Kim and Reinschmidt [2]	Risk reduction	ENR reports	Entropy	Positive
Adamu et al. [6]	Firm performance	Financial statistics	SR, ROE, ROA, PM	Negativan
Kim and Reinschmidt [16]	Firm performance	ENR reports	Entropy	Positive
Mahroum and Al-Saleh [28]	Economic development	Chile and Malaysia cases	Statistical analysis	Positive
Connaughton and Meikle [29]	Firm performance	Financial statistics	Statistical analysis	Neutral
Oyewobi et al. [30]	Firm performance	QS	HI, ROA, ROCE, PM	Positive
Jewell et al. [11]	Sustainable growth	QS, financial statistics	Growth timelines	Positive
Olivier and Root [12]	Firm performance	LR, financial statistics	ROE, ROA, ROCE	Positive
Raudszus et al. [31]	Firm performance	Merger and acquisition	Statistical analysis	Positive
Ruddock et al. [32]	Firm performance	Questionnaire survey	Statistical analysis	Positive
Verstina et al. [33]	National economy	LR	Statistical analysis	Neutral
Horta et al. [34]	Firm performance	Financial statistics	Truncated regression	Positive
Lee et al. [7]	Company insolvency	Macroeconomic variables	VECM, NSI	Neutral
Chen et al. [35]	Internationalisation	ENR reports	RDI	Positive
Sung et al. [5]	Firm performance	ENR reports	Clustering analysis	Neutral
Zhao et al. [36]	Enterprise niche approach	ENR reports	Enterprise niche theory	Positive
Ye et al. [17]	Diversification patterns	Financial statistics	Entropy	Positive
Han et al. [37]	Financial sustainability	Financial statistics	KMV model, HI	Positive
Jang et al. [13]	Business model types	ENR reports	ROA, RG, MS	Positive
Jang et al. [38]	Firm performance	Financial statistics	Regression analysis	Positive
Alashwal and Alduais [39]	Product diversification	Financial statistics	GMM	Positive
Jang et al. [40]	Business model types	ENR reports	Two-step cluster analysis	Positive
Wang et al. [14]	Geographical diversification	Financial statistics	Regression analysis	Neutral
Wang et al. [9]	Firm performance	ENR reports	ROA, TATR, DAR	Positive
Azman et al. [41]	Productivity	Financial statistics	GMM	Positive
Rhodes et al. [8]	Response strategies	QS	Qualitative methodology	Positive

Note: AIMA: Autoregressive integrated moving average; ROE: Return on equity; ROA: Return on assets; ROCE: Return on cash equity; PM: Profit margin; HI: Herfindahl index ; ENR: Engineering news record; AHP: Analytical hierarchy process; SAW: Simple additive weighting; LR: Literature review; QS: Questionnaire survey; VECM: Vector error correction mode; NSI: Network spread index; RDI: Regional diversification index; KMV: Kealhofer, McQuown and Vasicek model; RG: Revenue growth; MS: Market share; GMM: Generalised method of moments; TATR: Total asset turnover ratio; DAR: Debt–asset ratio

Researchers usually aim to reveal the DS results depending on the financial indicators, such as ROE, ROA, ROCE, and PM. Only one study conducted by Ravanshadnia et al. [27] aimed to benefit from the risk-spreading effect of DS at the project level. These authors utilised the analytical hierarchy process (AHP) to determine criteria weights and fuzzy simple additive weighting (SAW) to calculate project scores. The required data were gathered during a questionnaire survey designed during brainstorming sessions with experts. Finally, these authors concluded their study with a useful model for construction project selection to spread risk.

Considering the previous studies listed in Table 1, the DS results for construction companies can be divided into the following three categories: negative, neutral, and positive. In the majority (73.17 %) of the previously conducted studies, the DS had a positive effect on the performance of construction companies. However, to the best of our knowledge, no previously published study has evaluated the pre-diversification stage of DS; therefore, the present study is (to our knowledge) the first attempt to propose a fuzzy MCDM model on DS for construction companies at the corporate level.

3. Research methodology

Figure 1 presents a schematic of the proposed methodology, designed to guide construction companies in selecting an appropriate DS. This methodology, detailed in the subsequent sections, integrates a comprehensive literature review, expert elicitation, and FUSFA within an MCDM framework. Initially, the criteria influencing construction companies' diversification behaviour were identified following a systematic literature review. Subsequently, an FGD was conducted to refine these criteria and develop a structured questionnaire. Before deployment, the questionnaire was subjected to a pilot test with a representative sample to assess its clarity, comprehensiveness, and overall suitability for eliciting the required data. Based on the findings of the pilot test, revisions were made to finalise the instrument. Appropriate experts were selected to facilitate the data collection. The data were acquired in face-to-face interviews with senior construction managers. The obtained data were utilised during the fourth stage to develop the MCDM model and rank diversification alternatives using the FUSFA method. Finally, a sensitivity analysis was conducted to assess the impact of varying assumptions on the results.

This study endeavours to develop a novel decision-making model intended to assist construction companies in formulating a more effective DS. A salient research gap exists within the field of construction management stemming from the limited availability of comprehensive decision-making models explicitly designed to guide construction companies in the development of effective and tailored DS. This gap is further exacerbated by the under-utilisation of fuzzy logic and Bayesian-based approaches to address the inherent uncertainties and subjective factors that influence diversification decisions. The proposed decision-making model, designed to determine the optimal level of diversification for construction companies, represents a novel contribution to this field.

3.1. Identification of the DS criteria

This study assesses the diversification criteria for construction companies with industry professionals in two steps. A literature review was conducted to identify the most influential factors in DS, considering past studies on diversified construction companies. To achieve this, the Scopus search engine was utilised because it is considered as the most comprehensive academic search engine. Finally, four criteria were clarified: diversification strategy alternatives, reasons for diversification, company data and data indicators.

Companies can apply for DS at different levels. The most commonly used methods to determine companies' diversification levels are the standard industrial classification (SIC), Herfindahl index (HI), entropy measure (EM), and specialisation ratio (SR) [7, 13, 15, 17, 31, 37, 38, 41]. The SIC index can be impractical and insufficient in reflecting changes in the business environment in terms of the frequency of codes, emergence of different business models, technological developments, and innovative approaches. HI quantifies the level of market concentration instead of a company's degree of diversification [4, 43]. Kim and Reinschmidt [2, 15] and Ye et al. [17] utilised EM to quantify diversification. However, this requires financial data from companies. Therefore, in this study, the diversification level of companies was identified using SR; this index categorises companies into three diversification levels: highly diversified,

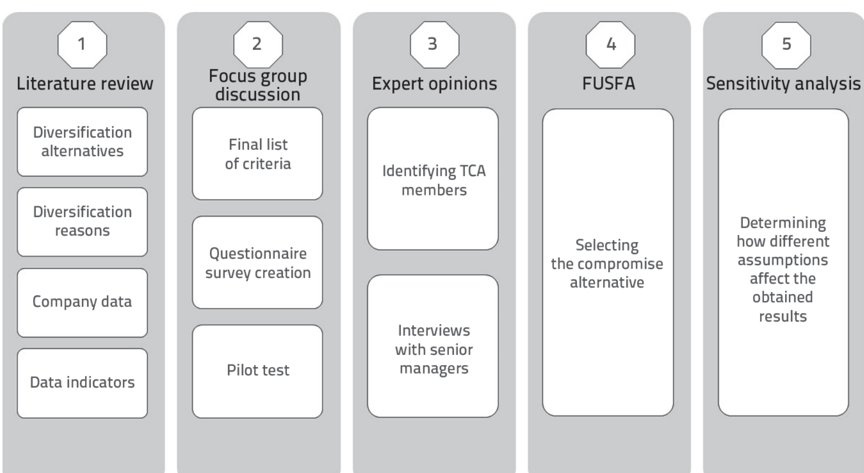

Figure 1. Research flow

moderately diversified, and non-diversified. These levels were calculated using the ratio of annual revenue from the largest business segment to the total revenue of a company. A company was classified as non-diversified if its SR is greater than or equal to 0.95. An area was considered highly diversified if the SR is lower than 0.70. Finally, it was classified as moderately diversified, if SR is between 0.70 and 0.95 (Table 2).

Table 2. Specialisation ratio (SR) classification

Level of diversification	SR
Non-diversified	SR ≥ 0,95
Moderately diversified	0,70 ≤ SR < 0,95
Highly diversified	SR < 0,70

Companies have several motivators to diversify [31]. A company may focus on specific reasons, rather than targeting all of them. In practice, numerous criteria are suggested without considering their significance in the decision-making process. In this study, the most suitable criteria were determined through literature review and FGD (Table 3). Finally, the five main reasons for diversification were determined (profitability, regular cash flow, risk spreading, market dominance, and backward integration). Growth performance can be quantified through annual percentage changes in gross revenue [16], and companies intend to sustain profitable growth in their business transactions [11]. Similarly, effective cash management is important; accordingly, construction companies employ DSs to provide profitable growth and regular cash flows [13, 38]. This strategy also reduces and spreads risks faced by companies in the construction industry [15, 31, 41]. Diversification is also preferred for market dominance to set prices above the competitive level for a company [2, 4, 29] and secure a competitive advantage against rivals. Finally, backward integration is preferred to increase efficiency by controlling the supply chain [6, 11].

It is almost impossible to obtain the exact financial data of a company because of confidentiality. Only a few construction companies in various countries publicly report their financial statements [16]. Therefore, the performance of diverse construction companies can be monitored using data from several companies. For example, an increase in turnover can be a considerable factor in a company's growth performance [9, 32]. Similarly, an increase or decrease in market share can be used to quantify a company's market dominance in an industry [2, 4, 29]. The number of international projects is important for construction companies when evaluating their performance in the international arena [5, 9, 13]. In terms of regular cash flow and healthy financial status, companies need on-time payments [20, 44]; additionally, diversification may improve the cash flow management of construction companies [45]. Finally, improved supply chain performance is the focal point for delivering the proper product in the proper quantity to the proper place on time [11, 12, 28] and is crucial for construction companies.

Monitoring data indicators can be regarded as important for maximising the reliability of company data. The following six indicators are critical for construction companies to follow company data: increase in sales volume [5, 34], increase in the number of customers [11, 38], minimisation of production costs [11, 34], fostering international reputation [9, 22], good credit score [7, 26] and delivering projects on time [46].

Additional data indicators may reveal a company's performance. However, these criteria should establish a mutual relationship with company data. For instance, a company should increase its sales volume to increase turnover. Similarly, an increasing number of customers may increase market share. The critical criteria for selecting, monitoring, and analysing the performance of a diversified construction company are presented in Table 3.

3.2. Data collection

The study employed FGD, a qualitative technique that facilitates the harmonisation of expert opinions on specific themes, recognised for its time and cost-effectiveness [54]. Five experts were invited to participate in the FGD to delineate the diversification criteria and provide information on the development of the subsequent questionnaire survey. The selection criteria for these experts were as follows:

- a minimum of 10 years of experience within the Turkish construction industry
- current incumbency in a senior management position within their respective organisations.

Potential experts were identified through professional networks and recommendations sourced from the Turkish Contractors

Table 3. Selected criteria

Diversification alternatives	Reasons of diversification	Company data	Data indicators
Increased diversification ($\tilde{A}_1$)	Profitable growth ($\tilde{N}_1$)	Turnover ($\tilde{V}_1$)	Sales volume ($\tilde{G}_1$)
Moderate diversification ($\tilde{A}_2$)	Regular cash flow ($\tilde{N}_2$)	Market share ($\tilde{V}_2$)	Number of customers ($\tilde{G}_2$)
Non-diversification ($\tilde{A}_3$)	Risk spreading ($\tilde{N}_3$)	International projects ($\tilde{V}_3$)	Production costs ($\tilde{G}_3$)
	Market dominance ($\tilde{N}_4$)	On-time payments ($\tilde{V}_4$)	International reputation ($\tilde{G}_4$)
	Backward integration ($\tilde{N}_5$)	Supply chain ($\tilde{V}_5$)	Credit score ($\tilde{G}_5$)
			Delivering projects on time ($\tilde{G}_6$)

Association (TCA), leveraging the organisation's extensive industry connections. Owing to logistical considerations, the FGD was conducted using an online platform. The session was extended for approximately 4 h, including a scheduled break. The authors facilitated the FGD by drawing upon their expertise in qualitative research methodologies and construction–management principles.

Before the FGD session, participants were provided with a concise summary of the salient findings from the literature review, emphasising DS, influencing factors affecting diversification decisions, and relevant performance indicators. The participants were explicitly encouraged to contribute to their experiential knowledge and perspectives, thereby critically evaluating and (where appropriate) refining the presented literature-based findings. Following the FGD and identification of relevant criteria, a three-part questionnaire survey was designed to collect data for model development. The initial section of the questionnaire aimed to gather background information from the respondents. The second section incorporated five-point Likert-type questions to assess the respondents' perceptions of the identified criteria through linguistic expressions. Finally, the third section comprised an open-ended question designed to elicit the respondents' general views and recommendations.

A pilot study was conducted with 20 senior managers from Turkish construction companies to ensure the relevance of the questionnaire and address potential practical concerns. Based on feedback received during the pilot study, modifications were made to enhance the clarity and usability of the questionnaire. The model was subsequently developed using data collected through a questionnaire. This survey was administered to senior managers who were members of the TCA. The decision to target TCA members was based on the fact that this cohort collectively encompassed approximately 70 % of all domestic contracting work and 90 % of all international contracting work undertaken by Turkish construction companies. Furthermore, almost 75 % of TCA members were actively engaged in diverse aspects of the construction sector, including manufacturing, engineering, and consulting.

For sampling and data collection, the target population consisted of 80 TCA members selected because of their primary business focus on construction contracts. Recognising the potential challenges associated with confidentiality, heavy workloads, and potential unwillingness to participate, 40 of the 80 targeted companies ultimately agreed to participate in the research study. The experts were evaluated based on quality rather than quantity. They were selected from the top construction companies in Turkey to eliminate possible quality issues. This sample size was deemed acceptable based on the rationale that the threshold value for a reasonably valid representation of the total population (TCA members in this instance) is a sample size of at least 30. Accordingly, the participant ratio (i.e. 50.0 %) and expert profiles (detailed in Table 4) were considered sufficient for this study. Finally, the questionnaires were administered in face-to-face interviews conducted at the respondents' offices. The decision to conduct face-to-face interviews was based on the understanding that this modality fosters rapport and trust, which are deemed essential for eliciting candid responses regarding sensitive company strategies and performance indicators. This interactive approach facilitates the clarification of ambiguities and probes for deeper insights, thereby enhancing data completeness and accuracy [55]. To promote data integrity, the respondents were explicitly assured of anonymity and data confidentiality to mitigate potential social desirability biases.

Table 4. Profile of the sample group

Position	Frequency	Percentage
Deputy general manager	8	20.0
General manager	6	15.0
Business development director	5	12.5
Tender manager	4	10.0
Project coordinator	3	7.5
Chairman of the board of directors	2	5.0
Planning manager	2	5.0
Project manager	2	5.0
Executive board member	2	5.0
General coordinator	1	2.5
Manager	1	2.5
Construction group coordinator	1	2.5
Consultant	1	2.5
Technical office manager	1	2.5
Budget and planning director	1	2.5
Experience in the construction industry		
1–5 years	0	0.0
6–10 years	0	0.0
11–15 years	5	12.5
16–20 years	7	17.5
> 20 years	28	70.0
Experience in their current companies		
1–5 years	6	15.0
6–10 years	8	20.0
11–15 years	7	17.5
16–20 years	8	20.0
> 20 years	11	27.5

There are several fuzzy membership functions available in the literature. Fuzzy data were expressed by the membership values (μ) ranging from zero to one. Although different types of membership functions (e.g. triangular or trapezoidal) can be utilised, a triangular membership function is more suitable for the linguistic assessment of experts in comparison with others. Figure 2 illustrates the boundaries of the triangular fuzzy membership functions of the answers provided by the experts during the questionnaire survey. To utilise fuzzy data in the FUSFA, a defuzzification process was conducted to convert fuzzy numbers into crisp numbers using the center of gravity (CoG) method, which is the most prevalent method [17]. Equation (11) expresses the related calculation process, where z* represents the defuzzified number, and ∫ represents the algebraic integration operator (Figure 3).

$$z^* = \frac{\int \mu_c(z)z\,dz}{\int \mu_c(z)dz} \tag{1}$$

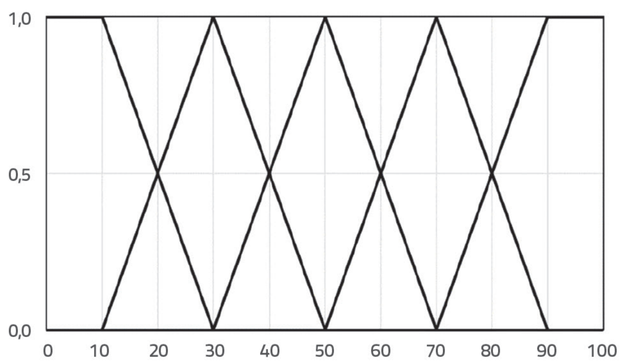

Figure 2. Representation of membership functions

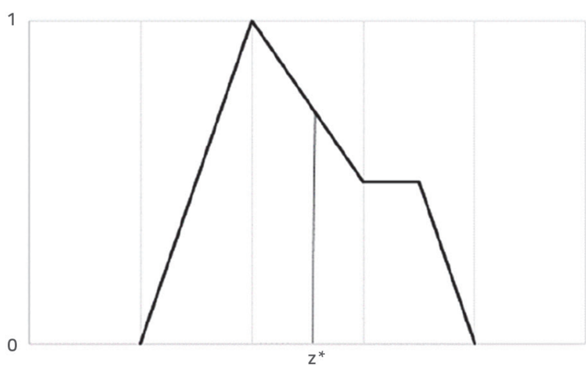

Figure 3. Representation of defuzzification using the center of gravity

3.3. The method of fuzzy states and actions - FUSFA

In the construction industry, it is almost impossible to estimate the exact values using qualitative decision-making criteria [27]. Moreover, the characteristics of the construction industry differ from those of other industries because of the vagueness of alternatives and states [35]. The Bayesian theorem defines how a person's beliefs should be combined with their objectives to make optimal decisions [47]. The integration of fuzzy sets using the Bayesian method is useful for obtaining approximate results in cases of uncertainty [48]. Tanaka et al. [42] first solved decision-making problems by using fuzzy actions, states, and information based on a Bayesian approach. In the literature, many studies have recently been performed using the fuzzy-focused Bayesian approach; for instance, for quality cost estimation [49], for business valuation [50], for entropy localisation [51], and for assessing investment attractiveness [52]. As a fuzzy Bayesian approach, FUSFA aims to select a compromise among fuzzy alternatives for fuzzy states [42].

The FUSFA presents a compelling alternative to traditional decision-making methods commonly employed in construction, particularly when confronted with the complexities and uncertainties inherent in DSs. Unlike approaches such as the AHP, analytic network process, Monte Carlo simulations, cost–benefit analysis, and multi-attribute utility theory, FUSFA exhibits superior capacity for managing fuzziness and imprecision through the utilisation of fuzzy sets, directly incorporating expert opinions and linguistic assessments. A key advantage lies in its unique integration of probability theory and fuzzy logic, enabling a more holistic analysis that considers both random events and subjective knowledge while also leveraging Bayesian principles for balanced decision-making. This allowed the consideration of objective data. Furthermore, FUSFA enables the simultaneous evaluation of multiple, often conflicting, criteria such as financial, operational, competitive, and strategic considerations within a unified framework. The values in the framework can be adapted to any region or for any expert; in this case, subjective opinions can be avoided using objective data. Its inherent adaptability and capacity to represent real-world vagueness render FUSFA a potent tool in scenarios where traditional methods may prove inadequate, although the optimal choice ultimately depends on the specific characteristics of the decision problem at hand. Therefore, in this study, FUSFA was utilised to develop an MCDM method owing to its advantages in terms of suitability, stability, and mathematical calculations.

Prior probabilities express prior knowledge of the states of nature. Let $S = \{s_1, s_2, ..., s_n\}$ be a set of possible states of nature. The probability that these states occur is expressed by Eq. (2).

$$P = \{p(s_1), p(s_2), ..., p(s_n)\} \text{ gdje je } \sum_{i=1}^{n} p(s_1) = 1 \tag{2}$$

A choice can be made among a set of alternatives $A = \{a_1, a_2, ..., a_m\}$. For a given alternative (a_j), a utility value (u_{ji}) is assigned by decision makers if the future state of nature turns out to be state (s_i). These utility values should be determined by decision makers because they express the value or cost for each alternative-state pair, that is, for each a_j-s_i pair. In FUSFA, the expected utility for the fuzzy alternatives is calculated using Eq. (3).

$$E\left(u_j \middle| \tilde{M}_t\right) = \sum_{S=1}^{n} u_{js} p\left(\tilde{F}_s \middle| \tilde{M}_t\right) \tag{3}$$

where $p(\tilde{F}_s|\tilde{M}_t)$ is the posterior probability of a fuzzy state that depends on the fuzzy information and is calculated using Eq. (4).

$$p\left(\tilde{F}_s \middle| \tilde{M}_t\right) = \frac{\sum_{i01}^{n} \sum_{k=1}^{r} \mu\tilde{F}_s(s_i)\, \mu\tilde{M}_t(x_k)\, p(x_k|s_i)\, p(s_i)}{p(\tilde{M})} \tag{4}$$

where $p(\tilde{M})$ s the marginal probability of the fuzzy states using fuzzy information and is calculated using (5).

$$p\left(\tilde{M}\right)=\sum_{k=1}^{n}\mu\tilde{M}_{t}\left(x_{k}\right)p\left(x_{k}\right) \tag{5}$$

The prior probabilities can be updated using new information. Thus, the obtained data $X = \{x_1, x_2, ..., x_r\}$ (where x_k, (k = 1, 2, ..., r)) are expressed as conditional probabilities $p(x_k|s_i)$ assessed according to s_i. Additionally, the symbol $p(x_k)$ is the marginal probability of the data and can be calculated using (6).

$$p\left(x_{k}\right)=\sum_{i=1}^{n}p\left(x_{k}\left|s_{i}\right.\right)p\left(s_{i}\right) \tag{6}$$

4. Results

This section describes the computational procedures employed in the proposed model. Specifically, it details the process based on which a decision maker can utilise the framework focussing on the derivation of expected utility values for diversification alternatives through the application of the FUSFA approach. This presentation encompasses key intermediate analytical stages, including the construction of relationship matrices, assessment of prior probabilities, and evaluation of data indicator predictability. Furthermore, this section explores the implications of these findings, highlighting salient insights into the optimal DS for construction companies operating within the studied context, and the salient factors influencing these strategic decisions.

4.1. Expected utility value of fuzzy diversification alternatives

The expected utility values of the fuzzy diversification alternatives were calculated using FUSFA according to the nine steps described below (Table 5). In the first five steps, the data gathered from experts were prepared for use in the FUSFA calculations. To do so, the relationship matrices, prior probabilities of company data, and predictability of data indicators were determined and are presented in Table 6. In this process, the fuzzy set theory and linguistic expressions were utilised. Subsequently, the FUSFA calculation was conducted in four steps:

- marginal probabilities of data indicators
- marginal probabilities of fuzzy sets
- posterior probabilities of fuzzy state-diversification reasons
- expected utility values of diversification alternatives.

Table 7 presents the results. Although the baseline parameter values employed in this study were empirically derived from a specific cohort of professionals within the Turkish construction industry, the inherent architectural design of the model allows decision-makers to operate in alternative contexts to adapt readily these parameters. This adaptation is predicated on the incorporation of domain-specific expertise and a thorough understanding of the prevailing local market conditions. This inherent architectural flexibility enables users to customise the model, reflecting their unique operational environments and strategic priorities, thereby enhancing its utility and facilitating broader adoption across diverse contexts.

4.1. Relationship matrix $\tilde{A}_i$ - $\tilde{N}_j$

The relationship matrix (M_1) was constructed based on expert judgments regarding the interaction between diversification alternatives and reasons for diversification, as presented in Table 3. The participants expressed their opinions using linguistic variables, and the corresponding fuzzy numbers were designated as very ineffective (0, 20, 30), ineffective (10, 30, 50), partially effective (30, 50, 70), effective (50, 70, 90), or very effective (70, 90, 100). A combination of fuzzy responses for the $\tilde{A}_i$ - $\tilde{N}_j$ pair is shown in Figure 5, and the defuzzification process is explained below as an example using (1). Figure 5 illustrates the integration of expert judgments regarding the relationship between the "highly diversified' alternative and "profitable growth". The elicited responses are aggregated to construct a novel fuzzy

Table 5. Model steps

Step number	Abbreviation	Description	Calculation
1	M_1	Relationship between div. alternatives – Div. reasons	Defuzzification of experts' judgements
2	M_2	Relationship between div. reasons – Company data	Defuzzification of experts' judgements
3	M_3	Relationship between company data – Data indicator	Defuzzification of experts' judgements
4	M_4	Prior probabilities of company data	Defuzzification of experts' judgements
5	M_5	Predictability of data indicator	Defuzzification of experts' judgements
6	$p(\tilde{G}_l)$	Marginal probabilities of data indicators	M_3, M_4 and (6)
7	$p(\tilde{M}_r)$	Marginal probabilities of fuzzy states	$p(\tilde{G}_l)$, M_5 and (5)
8	$p(\tilde{N}_s\|\tilde{B}_t)$	Posterior probabilities of fuzzy states	M_2, M_3, M_4, M_5, $p(\tilde{M}_1)$ and (4)
9	$E(u_j\|\tilde{B}_t)$	Expected utility value	M_1, $p(\tilde{N}_1\|\tilde{B}_1)$ and (3)

Table 6. Expert judgments

M_1 matrix	$\tilde{N}_1$	$\tilde{N}_2$	$\tilde{N}_3$	$\tilde{N}_4$	$\tilde{N}_5$	
	69.66	69.66	69.66	50.00	54.01	
	50.00	59.99	54.01	50.00	54.01	
	54.01	54.01	50.00	50.00	50.00	
M_2 matrix	$\tilde{V}_1$	$\tilde{V}_2$	$\tilde{V}_3$	$\tilde{V}_4$	$\tilde{V}_5$	
$\tilde{N}_1$	0.206121436	0.198602684	0.198602684	0.206121436	0.191735596	
$\tilde{N}_2$	0.206121436	0.198602684	0.256150028	0.206121436	0.191735596	
$\tilde{N}_3$	0.190817845	0.148041919	0.198602684	0.190817845	0.177500089	
$\tilde{N}_4$	0.190817845	0.256150028	0.198602684	0.190817845	0.191735596	
$\tilde{N}_5$	0.206121436	0.198602684	0.148041919	0.206121436	0.247293124	
M_3 matrix	$\tilde{G}_1$	$\tilde{G}_2$	$\tilde{G}_3$	$\tilde{G}_4$	$\tilde{G}_5$	$\tilde{G}_6$
$\tilde{V}_1$	0.22014894	0.1495252	0.14952520	0.14952520	0.19285180	0.13842363
$\tilde{V}_2$	0.20878515	0.1828970	0.14180691	0.18289705	0.14180691	0.14180691
$\tilde{V}_3$	0.18015827	0.1396834	0.13968344	0.18015827	0.18015827	0.18015827
$\tilde{V}_4$	0.16875488	0.1687548	0.15622559	0.16875488	0.16875488	0.16875488
$\tilde{V}_5$	0.16088769	0.1608876	0.20750670	0.14894250	0.16088769	0.16088769
M_4 matrix	$p(\tilde{V}_1)$	$p(\tilde{V}_2)$	$p(\tilde{V}_3)$	$p(\tilde{V}_4)$	$p(\tilde{V}_5)$	
	0.25454	0.19735	0.18270	0.18270	0.18270	
M_5 matrix	$\tilde{B}_1$	$\tilde{B}_2$	$\tilde{B}_3$			
$\tilde{G}_1$	0.00	0.9198	0.0802			
$\tilde{G}_2$	0.00	1.00	0.00			
$\tilde{G}_3$	0.00	1.00	0.00			
$\tilde{G}_4$	0.00	0.9198	0.0802			
$\tilde{G}_5$	0.1948	0.8052	0.00			
$\tilde{G}_6$	0.1948	0.8052	0.00			

membership function, which is subsequently defuzzified to derive a representative crisp value. In this framework, a decision-maker retains the capacity to modify the relationship between diversification alternatives and reasons to identify the optimal strategic path for their specific organizational context. All the remaining fuzzy responses were subjected to defuzzification using the CoG method, and the resulting crisp values are presented in Table 6. However, these values are not immutable; instead, decision-makers retain the capacity to revise them to incorporate explicitly their own judgments regarding diversification strategies and related criteria. Consequently, the optimal diversification alternative is contingent on the decision maker's specific circumstances and subjective assessments.

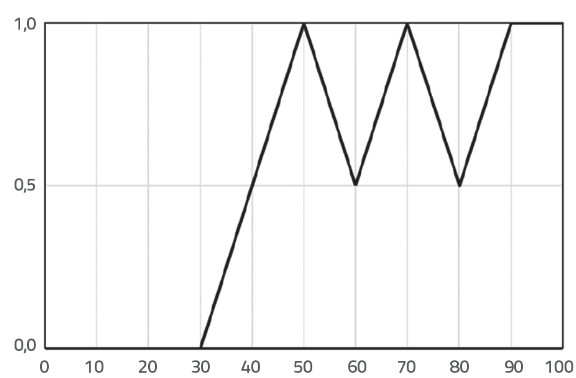

Figure 4. Combination of fuzzy responses for the $\tilde{A}_i$ - $\tilde{N}_1$ pair

$$z^* = \frac{\int_{30}^{50}(0,05z-1,5)\,zdz+\int_{50}^{60}(-0,05z+3,5)\,zdz+\int_{60}^{70}(0,05z-2,5)\,zdz+\int_{70}^{80}(-0,05z+4,5)\,zdz+\int_{80}^{90}(0,05z-3,5)\,zdz+\int_{90}^{100}zdz}{\left(\int_{30}^{50}(0,05z-1,5)\,dz+\int_{50}^{60}(-0,05z+3,5)\,dz+\int_{60}^{70}(0,05z-2,5)\,dz+\int_{70}^{80}(-0,05z+4,5)\,dz+\int_{80}^{90}(0,05z-3,5)\,zdz+\int_{90}^{100}dz\right)} = 69,66$$

4.1.1. Relationship matrix $\tilde{N}_j$ - $\tilde{V}_k$

In the second step, experts evaluated the relationship between the reasons for diversification and company data using linguistic variables such as very unrelated (0, 20, 30), unrelated (10, 30, 50), partially related (30, 50, 70), related (50, 70, 90), and very related (70, 90, 100). These variables were scaled using the same boundaries as those used in the first step. After defuzzification of the fuzzy answers, the relationship matrix $M_2$was constructed (Table 6).

4.1.2. Relationship matrix $\tilde{V}_k$ -$\tilde{G}_i$

M_3 represents the relationship matrix between the company data ($\tilde{V}_k$) and data indicators ($\tilde{G}_i$). Similar to the second step, M_3 was formed based on expert judgments using linguistic variables, such as very unrelated (0, 20, 30), unrelated (10, 30, 50), partially related (30, 50, 70), related (50, 70, 90), and very related (70, 90, 100). The answers given were then de-fuzzified, and the relationship matrix M_3 was constructed (Table 6).

4.1.3. Prior probabilities of company data

The respondents were asked to evaluate the probabilities of obtaining reliable company data and classify them as follows:
- very low
- low
- medium
- high
- very high.

The answers were defuzzified using the CoG method and normalised to an orthogonal structure using the Bayesian approach. According to Table 6, a company's turnover ($\tilde{V}_1$) data have the highest prior probability value, followed by the market share ($\tilde{V}_2$) data. Thus, matrix M_4 was calculated.

4.1.4. Predictability of data indicators

Previous studies have questioned the reliability of financial data obtained from construction companies. To maximise the reliability of the data, the predictability levels of the data indicators were evaluated by experts using the following linguistic variables:
- unpredictable ($\tilde{B}_1$)
- partially predictable ($\tilde{B}_2$)
- predictable ($\tilde{B}_3$).

Thus, the predictability levels of the data indicators were classified based on the triangular membership function shown in Figure 4. Regarding the fuzzy Bayesian approach, the structure of the FUSFA enables the use of fuzzy numbers in conjunction with crisp numbers. Therefore, the M_5 matrix was formed (Table 6) and the obtained values were used as fuzzy numbers in the FUSFA calculations.

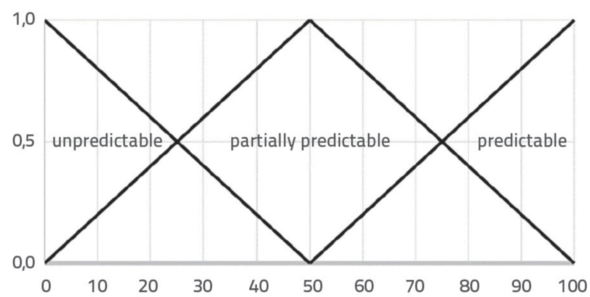

Figure 5. Representation of triangular membership function used for predictability

Table 7. Fuzzy states and fuzzy actions calculation outcomes

$p(\tilde{G}_1)$	$p(\tilde{G}_2)$	$p(\tilde{G}_3)$	$p(\tilde{G}_4)$	$p(\tilde{G}_5)$	$p(\tilde{G}_6)$
0.1903830	0.1599024	0.1580214	0.1651148	0.1702163	0.1563621
	$p(\tilde{M}_1)$	$p(\tilde{M}_2)$	$p(\tilde{M}_3)$		
	0.06362	0.90787	0.02851		
	$\tilde{B}_1$	$\tilde{B}_2$	$\tilde{B}_3$		
$\tilde{N}_1$	0.2007275	0.2006238	0.2008035		
$\tilde{N}_2$	0.2123277	0.2110573	0.2114601		
$\tilde{N}_3$	0.1826583	0.1812909	0.1808375		
$\tilde{N}_4$	0.2037496	0.2053690	0.2066115		
$\tilde{N}_5$	0.2005368	0.2016590	0.2002873		
	$\tilde{B}_1$	$\tilde{B}_2$	$\tilde{B}_3$		
$E(u_1)$	62.5158809	62.4664820	62.4635207		
$E(u_2)$	53.6577664	53.6440910	53.6407967		
$E(u_3)$	51.6563515	51.6508413	51.6531771		

4.1.5. Marginal probabilities of data indicators

The symbol $p(\tilde{G}_i)$ denotes the marginal probability of the data indicator required to calculate the posterior probabilities of the fuzzy states, $p(\tilde{N}_s|\tilde{B}_t)$. To achieve this, the relationship matrices M_3 and M_4 were used with (6), and the results obtained for all data indicators are presented in Table 7.

4.1.6. Marginal probabilities of fuzzy states

The marginal probabilities of the fuzzy alternatives $p(\tilde{M}_1)$ were determined using $p(\tilde{G}_i)$, M_5 and (5). The marginal probabilities for all data fuzzy states are listed in Table 7.

4.1.7. Posterior probabilities of fuzzy states

To calculate the posterior probabilities, $p(\tilde{N}_1|\tilde{B}_1)$ of fuzzy states M_2, M_3, M_4, M_5 and $p(M_1)$ were used in (4).

4.1.8. Expected utility value

The expected utility value was the final score. To reach the final decision, each $E(u_j|\tilde{M}_t)$ score was calculated using the data from M_1 and $p(N_1|B_1)$ based on (3).

4.2. Sensitivity analysis

In this analysis, the values of all $\tilde{A}_i$ - $\tilde{N}_j$ pairs were individually changed from 0 to 100 to observe the significance of its effect on the final decision. The final decision A_1 was the baseline value. Fifteen comparisons were performed, and the corresponding results are shown in Figure 6.
The reduction in utility values between high diversification and the reasons for diversification changes the results. For example, if a decision maker assigns a utility value lower than 30 for $\tilde{A}_1$ - $\tilde{N}_1$, $\tilde{A}_1$ - $\tilde{N}_2$ and $\tilde{A}_1$ - $\tilde{N}_3$ or lower than 10 for $\tilde{A}_1$ - $\tilde{N}_4$ and $\tilde{A}_1$ - $\tilde{N}_5$, the results become moderately diversified. However, an increase in the assigned values did not change the final decision. Considering the moderately diverse alternatives and the reasons for diversification, an increase in the utility value of $\tilde{A}_2$ - $\tilde{N}_1$ has the potential to change the result to highly diversified. If the utility value assigned to $\tilde{A}_2$ - $\tilde{N}_1$ was higher than 90, the result became moderately diverse. Finally, the utility values of the relationships between non-diversification states and reasons for diversification have no significant impact on decisions. As a result, (i) a decrease in the assigned values between high-diversification states and reasons for diversification, and (ii) an increase in the assigned values between moderate diversification states and reasons for diversification affect the final decision.

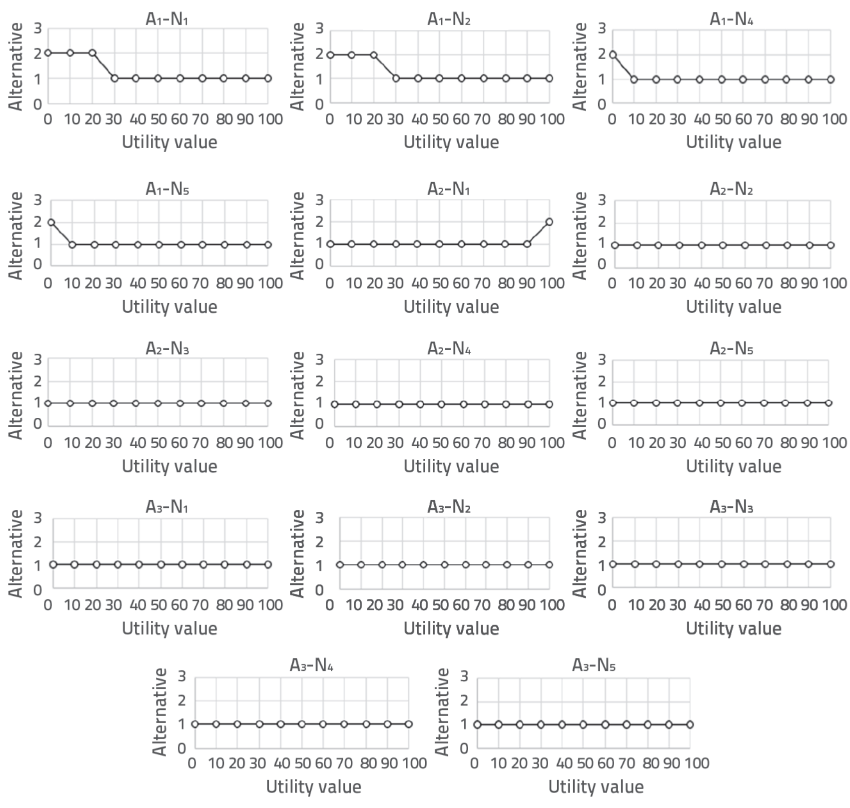

Figure 6. Sensitivity analysis results

5. Discussion

This study proposed an MCDM model to assist construction companies to formulate DSs. The FUSFA approach was employed for the computational analysis, and a sensitivity analysis was subsequently conducted to broaden the scope of the findings. However, it is important to acknowledge that MCDM methods, such as the fuzzy approach utilised herein, typically yield compromised solutions rather than absolute optima. These methodologies inherently balance multiple, often conflicting, criteria, and their outcomes are influenced by the subjective nature of preference elicitation and the approximate reasoning capabilities of fuzzy logic. Therefore, the findings presented in this section should be interpreted as representing the "most preferred' diversification alternative, recognising the fact that this alternative offers the most desirable balance of trade-offs given the available data and the specified preferences of the decision-makers. The following sections discuss the results obtained by using this analytical framework.

5.1. Compromising alternative

From the perspective of construction professionals, high diversification is more advantageous than other diversification options. High diversification has the potential to create profitable growth, provide regular cash flows, and spread construction risk. Business strategies are usually implemented to direct a company towards growth [19]. Profitable growth requires the improvement of existing capabilities and the exploration of new competencies [34]. Large construction companies can employ DSs to achieve profitable growth and sustain their competitiveness in other sectors [41]. However, Jrew et al. [11] noted that some construction professionals consider DS an essential medium for profitable growth, while others focus on their core competencies in growing markets. These conflicting views may emerge for several reasons, such as the influence of senior managers, experience, and company objectives. As profitable growth may require a long run, it may not be suitable for companies focusing on short-term targets.
Poor cash-flow management can cause delays in construction projects [27], cause construction companies to fail, and adversely affect the construction supply chain [8], particularly during macro-economic crises. Diversified firms are stronger than un-diversified ones [23]. The findings indicate that high diversification yields the best performance in enabling regular cash flow for construction companies and that providing regular cash flow has the highest score among diversification reasons for all diversification alternatives. Turkish construction companies prefer DSs to generate cash [45]. Similarly, construction companies in the United Kingdom choose DSs to maximise profits and sustain regular cash flows [32].
Respondents were asked to evaluate the risk-spreading effects of DSs, and findings showed that construction companies should prefer to be highly diversified to spread their risks. Previous studies have also emphasised DSs as a measure that construction companies are forced to adopt when facing high-business risks [9]. As evidenced by Yee and Cheah [24], un-diversified firms face higher levels of risk, whereas diversification has a spreading effect on business risks. Similarly, Kim and Reinschmidt [2] recommended that construction companies diversify their risk-management practices. However, DSs may also pose risks. Some contractors have diversified and engaged in activities in other geographical markets in different industries. As venturing into a new region is risky, the risks to be overcome should not be increased by entering a new industry [17]. Although senior manager risk attitudes may affect the DS decision-making process, it is difficult to categorise these risk attitudes.

The effects of the remaining two reasons for diversification on company performance are similar for each diversification alternative. None of the diversification alternatives is superior to others in dominating the construction market. Although high and moderate DS alternatives have a stronger effect on backward integration, there is no difference between these two alternatives in terms of their contributions to company performance.
DS provide stable business performance for construction companies. However, this argument is not valid in all the diversification scenarios. Previous studies have revealed neutral effects of DSs on company performance (Table 1). Kim and Reinschmidt [16] found no significant (positive) relationship between growth and market diversification, whereas Ibrahim and Kaka [10] and Adamu et al. [6] stated that diversification has a negative effect on the financial performances of construction companies. Nevertheless, the findings of the current study are consistent with those of most previous studies. Construction companies should diversify, and their largest business segment should have an annual revenue of less than 70 % of their total revenue. It is a broadly accepted finding that highly diversified construction companies usually have higher profits and steady growth rates than moderately diversified ones [44]. Additionally, an un-diversified company can be associated with under-performance, a moderately diversified company can be considered to outperform, and a highly diversified company can have the best performance [12]. Hence, non-diversified construction companies are likely to fail sooner than diversified ones [2].

5.2. Reasons for diversification and company data

The results of the relationship between the reasons for diversification and company data provide a basis for discussing how these reasons and data can be utilised to facilitate the decision-making process. The literature focusing on the diversification of construction companies is relatively limited. Therefore, these findings have great potential as they are the first that demonstrate this relationship.
Diversified companies should monitor their annual turnovers and on-time payment records to ensure profitable growth. This is because growth can be achieved by increasing the turnover [32]. During macro-economic recession periods, construction companies are particularly enthusiastic about diversifying to obtain sufficient turnover [27]. Another major factor responsible for profitable growth is on-time payments. Late or incomplete payments negatively affect contractors' cash flows and financial status [6]. Contractors should carefully consider payment terms and clients' ability to make on-time payments to ensure positive cash flow [25]. On-time payments are crucial for assessing working capital requirements for successful contract execution. If

payments are delayed, the risks to construction companies will naturally increase. These findings indicate that construction companies should focus on international projects to provide regular cash flows and spread business risks. This statement is supported by Kim and Reinschmidt [2]. Another reason for diversification is that market dominance strongly correlates with market share. As the diversification of related businesses will cause an increase in market share, construction companies should extend their market share to remain competitive [46]. The final reason for this diversification was backward integration. The most critical risk factors in the construction supply chain are funding, shortage of materials and equipment, poor cash flow, terrorism, and unusual weather conditions [32]. Backward integration is the most important factor that allows construction companies to achieve better supply chain performance and reduce the aforementioned risks.

Consequently, this study enabled a comparative discussion of company data and the reasons for diversification. Although more criteria could be assessed to extend the scope of this research, this is the first attempt to reveal these relationships in the diversification literature.

5.3. Company data and data indicator

Company data were associated with data indicators to enable better observation by decision makers. Thus, the reliability of company data can be maximised during the decision-making process. The findings demonstrated that an increase in turnover can be observed from an increase in sales volume. This was also supported by Ibrahim and Kaka [10]. For many diversified companies, the sales volume and level of diversification increased together [5]. Similarly, it was found that a higher turnover can leverage the credit score of a construction company. Sung et al. [5] noted that good management of bank loans and credit has a major impact on turnover growth. Market share is a noteworthy indicator of market dominance, that is, the ability to set prices above competitive levels. Because the market share is strongly correlated with sales volume, a decision-maker who seeks to diversify to provide market dominance may evaluate market share by tracking sales volume. Sales volume, international reputation, credit scores, and on-time completion are identified as major indicators for increasing the number of international projects, thereby improving financial performance [34]. On-time payments and other company data can be traced by using several indicators. The results show that almost all the data indicators, except the minimisation of production costs, have equal potential to reflect on-time payment records. Finally, a construction company may associate production cost minimisation with a reduction in supply chain problems. This is because a successful DS can improve the cost-minimisation strategy through economies of scale [11].

6. Implications and limitations

To our knowledge, to date, no study has proposed a pattern for designing diversification criteria for construction companies. Previous studies have often utilised financial data gathered from the annual reports of diversified construction companies. However, diversification criteria schemes should be processed explicitly and systematically using expert knowledge. The results indicated that construction company managers should analyse the relationship between company data and the reasons for diversification. Data indicators and probability levels of criteria should also be considered during the decision-making process. Finally, according to the sensitivity analysis, the value assignments of selected pairs of criteria have the potential to change the concluding decisions.

Although this study was conducted with Turkish construction companies to present a holistic industrial overview, the proposed model can be applied to other industries for research and practical use and utilised by any construction company individually-both in Turkey and in other countries—to establish a DS. Thus, the model can be modified by modifying the criteria and their weights according to the specific requirements of the industry or company. The effects of time on the weights and scores of the criteria were also examined. Finally, a software program for the model can be developed for practitioners to be useful and to avoid the complexities of the computation process.

This study is associated with specific inherent limitations. The relationship between diversification and organisational performance is a complex interplay influenced by various factors, including the specific type and mode of diversification implemented, top-tier management capabilities, and the overarching industrial structure in which the organisation operates. While this research focused primarily on the degree of diversification as a key diversification alternative, future investigations could extend this model to encompass the nuances of diversification type and mode. Furthermore, the absence of qualitative factors, such as company culture, leadership effectiveness, employee morale, and risk attitudes of senior management, represents an additional limitation. Subsequent research may benefit from the integration of these considerations and potentially contribute to a more comprehensive and nuanced DS model. A questionnaire survey was administered to 40 diverse construction companies in Turkey. Another limitation of this study was the generalisability of the questionnaire. Although the number of participants was statistically satisfactory, extending the sampling group to national and international levels could change the results. These limitations should be considered when interpreting the results.

7. Conclusion

This study is considered to be the first attempt to create a decision-making model for DSs in construction, because DSs usually have positive effects on business performance. This study aims to develop a suitable model to help construction professionals select the most appropriate DSs. To achieve this, diversification alternatives and decision criteria were identified based on related literature and finalised after interviewing senior construction managers. The findings reveal that among the three diversification strategies (i.e. high diversification, moderate diversification, and non-diversification), high diversification is a compromised alternative for construction companies. The results also showed that the most critical company data to monitor diversification reasons were:

a) increases in turnover for profitable growth
b) increases in the number of international projects for regular cash flows and risk spreading,
c) increases in the market share for market dominance,
d) supply chain performance for backward integration.

Factors such as sales volume and credit score for turnover, sales volume for market share, and minimisation of production costs for good supply chain performance were found to be important indicators of company data. Finally, most data indicators were associated with the number of international projects and on-time payments. Despite the aforementioned limitations, this study presents a novel approach to diversification alternatives, reasons for diversification, company data, and data indicators to ensure competitive advantages in the construction industry. The criteria and model can be of great importance to both industrial practitioners and scholars for improving their understanding of diversification applications in the construction industry. Consequently, the proposed comprehensive DS model is expected to help construction companies both during the decision-making process and while observing company data and data indicators against possible DS failures.

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