# Innovating the bank-firm relationship: a spherical fuzzy approach to SME funding

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## Abstract

**Purpose** – Innovation in financing processes, enabled by the advent of new technologies, has supported the development of alternative finance funding tools. In this context, the study analyses the growing importance of alternative finance instruments (such as equity crowdfunding, peer-to-peer (P2P) lending, venture capital, and others) in addressing the small and medium enterprises' (SMEs) financing needs beyond traditional bank and market-based funding channels. By providing more flexible terms and faster approval times, these instruments are gradually reshaping the traditional bank-firm relationship.

**Design/methodology/approach** – To comprehensively understand this innovation shift in funding processes, the study employs a novel approach that merges three MCDA methods: Spherical Fuzzy Entropy, ARAS and TOPSIS. These methodologies allow for handling ambiguity and subjectivity in financial decision-making processes, examining the effects of multiple criteria, including interest rate, flexibility, accessibility, support, riskiness, and approval time, on the appeal of various financial alternatives.

**Findings** – The study's results have significant theoretical and practical implications, supporting SMEs in carefully evaluate financing alternatives and enables banks to better identify the main "competitors" according to the "financial need" of the firm. Moreover, the rise of alternative finance, notably P2P lending, indicates a shift towards more efficient capital access, suggesting banks must innovate their funding channels to remain competitive, especially in offering flexible solutions for restructuring and high-risk scenarios.

**Practical implications** – The study advises top management that SMEs prefer traditional loans for their reliability and accessibility, necessitating banks to enhance transparency, innovate, and adopt digital solutions to meet evolving financing needs and improve customer satisfaction.

**Originality/value** – The study introduces a novel integration of Spherical Fuzzy TOPSIS, Entropy, and ARAS methodologies to face the complexities of financial decision-making for SME financing, addressing ambiguity and multiple criteria like interest rates, flexibility, and riskiness. It emphasizes the importance of traditional loans, the rising significance of alternative financing such as P2P lending, and the necessity for banks to innovate, thereby enriching the literature on bank-firm relationships and SME funding strategies.

**Keywords** Alternative finance, Innovation processes, SMEs, Fuzzy, Banking

**Paper type** Research paper

# 1. Introduction

The advent of new technologies has innovated the firms' funding processes, leading to the development and growing adoption of alternative finance tools especially by small and medium-sized enterprises (SMEs) (Farag and Johan, 2021). Despite SMEs are the core of the global economy, as a fostering of innovation processes (Stefani *et al.*, 2020) and economic growth (OECD, 1997), an extensive literature body shows how these firms often experience financing constraints due to poor accounting and regulatory systems (Beck and Demirguc-Kunt, 2006), competition policies and practices. Therefore, affecting the supply of financing tools (Foltz, 2004), and generating a lack of awareness and knowledge of the available sources of alternative finance (Cook and Nixson, 2000), can exacerbate credit risk and transaction costs for SMEs.

In this scenario, traditional bank loans, while a primary source of funding, have proved inadequate due to their rigid conditions, exhaustive approval processes, and limited attention to the emerging needs of SMEs. Consequently, investigating alternative finance tools, as results of innovation processes in funding activities, has become a significant research stream, due to their increasing worldwide relevance (OECD, 2018). In this perspective, current studies show as SMEs are gradually looking beyond traditional banking boundaries to explore a range of other financial platforms, such as equity crowdfunding (Coakley and Lazos, 2021), peer-to-peer (P2P) lending (Stefanelli *et al.*, 2022), business angels, venture capital (Lerner and Nanda, 2020), factoring, leasing, private equity, bond issuance, and sovereign wealth funds. These instruments provide additional digital financing channels, offer more flexible terms, and sometimes guarantee prompter approval times. Unlike traditional banks, these innovative tools and services are characterised by competitive interest rates, greater flexibility and accessibility, customised client support and timely approval times. These innovative instruments slowly orient SMEs towards evaluating alternative financing strategies, partially reducing their dependence on the traditional banking channel and thus altering the conventional bank-firms relationship (Degryse and Ongena, 2001) in an open innovation framework (Yin and Li, 2023).

In this study, we aim to rank different funding alternatives for SMEs and find the best solution, among those available on the market, according to the specific firm's financing need. In this context, an innovative fuzzy methodology is employed to explore the role of alternative finance instruments in reshaping bank-firm relationships. The current study aims to answer the following questions:

*RQ1.* How should SMEs satisfy their funding needs?

*RQ2.* What are the most appropriate funding sources depending on SME needs?

Our approach integrates three methods such as (1) Spherical Fuzzy TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), (2) Entropy, and (3) Additive Ratio Assessment (ARAS). These techniques are suitable for dealing with the ambiguity and subjectivity often inherent in financial decision-making and enabling the investigation of the effects of multiple determinants (or criteria) on the attractiveness of various financial funding alternatives. The criteria encompass interest rate, flexibility, accessibility, support, riskiness, and approval time, which are selected based on extensive literature. Similarly, the alternative finance instruments are chosen in line with their demonstrated effectiveness in addressing SMEs' financing needs.

The study provides several theoretical and practical contributions to assess alternative funding sources available for SMEs. First, the study reiterates the crucial role that traditional loans still play in financing SMEs, mainly due to their reliability, accessibility, and predictability criteria. Nevertheless, alternative financing sources such as peer-to-peer (P2P)

lending and leasing are gradually gaining prominence, offering new opportunities for SMEs' funding needs and challenges for traditional banking institutions. Additionally, we analyse SMEs' financing preferences across three key firms' financial needs, such as: (1) new investments, (2) liquidity needs, and (3) debt restructuring. Particularly for high-risk SMEs undergoing debt restructuring, the flexibility and responsiveness of P2P lending and venture capital can offer valuable financial support. Our investigation shows the dominant role of traditional loans, the rising appeal of alternative financial channels, and the advantages linked to these alternatives according to SMEs' specific financing requirements.

The study contributes to two different literature streams. On one side, it expands the knowledge on innovation management field in firms' funding activities by examining the changing environment of financing options available to small and medium-sized enterprises (SMEs) with a careful examination of threats and opportunities correlated to these tools. On the other hand, it contributes to the bank-firm relationship body of literature, reinforcing the importance of traditional loans and highlighting the emerging relevance of alternative finance channels. Our findings underscore the mandatory need for banks to adapt and (re) innovate their practices to safeguard their competitiveness in a dynamic financial industry. The study offers understandings for policymakers, suggesting the need for target oversight and regulation of new digital financial platforms to ensure and safeguard SMEs' interests. Furthermore, the study underscores the need for SMEs to carefully evaluate the available financing options to address their financial needs and long-term strategy optimally.

The remainder of the paper is organized as follows. Section 2 reviews and discusses the existing literature, identifying the research gap. Section 3 describes the multiple MCDA methods applied. Section 4 exhibits the methods' ranking results. Section 5 discusses the main findings. Finally, Section 6 concludes the paper, offering understandings and implications for academics and practitioners.

## 2. Bank credit, alternative finance, and bank-firm relationship

### 2.1 Literature review

The literature review systematically addresses the role of relationship lending in SME financing, emphasizing its reliance on "soft" information from banks' interactions with businesses (Berger and Udell, 1995; Baas and Schrooten, 2006; Cotugno et al., 2013a, b). It highlights risks linked to SMEs' dependence on a single banking relationship, noting that diversifying financial relationships could mitigate default risks (Agostino et al., 2012; Cotugno et al., 2013a, b). The financial crisis of 2007–2009 demonstrated the crucial role of Mutual Guarantee Institutions (MGIs) in providing stability to SME financing (Bartoli et al., 2013). Further, the literature explores demographic influences on financing access, revealing those female entrepreneurs experience more severe credit constraints (Bellucci et al., 2010). The impact of digital technologies has transformed traditional bank-firm relationships, reducing the importance of geographical proximity and enhancing the role of digital connections in finance (Jakšič and Marinč, 2019; Thakor, 2020; Fasano and La Rocca, 2023). The integration of fintech and alternative financing tools is also examined, noting their potential to alleviate bank fragility and expand credit access for SMEs (Casey and O'Toole, 2014; Mamatzakis et al., 2021; Pierrakis, 2019; Sheng, 2021; Stefanelli et al., 2022). This body of work underscores a significant shift in SME financing practices, influenced by both technological advancements and evolving market dynamics.

The relationship lending model plays a significant role in the broader literature that analyses how SMEs fulfil their financial needs (Cotugno and Stefanelli, 2012; Cotugno et al., 2013a, b). In this perspective, Agostino et al. (2012) warn of the dangers of SMEs' over-reliance on a single bank, which could lead to an increased likelihood of default. Instead of diversifying their borrowing relationships, SMEs could minimise the concentration risk and

consequently decrease their default probabilities. As studies emphasize, a fundamental method of SMEs financing is relationship lending or relationship banking, a technique based on "soft" information which is mainly generated by banks' experience with a given lender (Berger and Udell, 1995; Baas and Schrooten, 2006; Cotugno *et al.*, 2013a, b; Ferri and Messori, 2000; Fasano and La Rocca, 2024). However, the lack of firms' data and information asymmetry problems can exacerbate the rationing of credit supply to firms. Consequently, since relationship lending leads to high loan interest rates, SMEs suffer from high external funding costs (Baas and Schrooten, 2006).

During the financial crisis of 2007–2009, Mutual Guarantee Institutions (MGIs) provided a safety net for SMEs (Bartoli *et al.*, 2013), extending their reach beyond collateral provision and signalling roles in bank lending policies. During the systemic crisis, this process has contributed to ensuring the financing of SMEs. These dynamics where not specifical to the Great Financial Crisis but occurred also during the sovereign debt crisis (Roux and Savignac, 2024).

Some scholars have also investigated the elements that could affect SMEs' lending constraints, founding that gender issues and other characteristics influence SMEs' financing accessibility. In this perspective, Bellucci *et al.* (2010) empirically demonstrate that female entrepreneurs encounter more severe credit availability constraints compared to their male counterparts, emphasizing a gender bias in SME financing (Bu *et al.*, 2024). Contrary to the conventional belief that large and foreign banks avoid SMEs, De la Torre *et al.* (2010) contend that these banks, usually supported by new technologies and efficient risk management systems, perceive SMEs as a strategic sector, opening alternative forms for SME funding.

Over the past decade, the rise of digital technologies has significantly transformed the traditional relationship between banks and firms. This shift has sparked increased scholarly interest, leading to numerous studies focused on how digitalization influences banking operations. Research by Jakšič and Marinč (2019), Thakor (2020), and Fasano and La Rocca (2023) highlights the profound effects of digitalization on SME financing. Although geographical proximity to banks has become less critical in online interactions, Fasano and La Rocca (2023) note that personal relationships still play a crucial role, particularly in collecting fundamental qualitative information during debt negotiations. The growing preference for alternative finance methods has also been explored by Casey and O'Toole (2014), who examined whether banking constraints have pushed firms towards other financing options such as trade credit and informal loans. Their findings suggest that firms facing credit restrictions are more inclined to use these alternative sources, particularly larger firms or those anticipating growth. Moreover, firms with higher debt levels are found to be more likely to engage in alternative financing.

In the literature stream focusing on investigating alternative finance tools and their impact on the banking system, the study of Mamatzakis *et al.* (2021) proposed a new method of modelling alternative finance in the euro area. The authors exhibit how alternative finance solutions, mitigating bank fragility, could ease credit constraints for SMEs. In fact, lower risk-taking would ease pressures on bank fragility, which has significant implications for regulators and supervisors tasked with establishing a secure and financially stable banking system (Lou *et al.*, 2024). Lastly, a more recent literature stream (Pierrakis, 2019; Sheng, 2021; Stefanelli *et al.*, 2022; Li *et al.*, 2024) has analysed the impact of Fintech platforms (e.g. P2P lending or equity crowdfunding) on banks' credit offers, finding that these instruments, mitigating the information frictions in the loan processes, could act as a useful alternative financial circuit to bank credit (Stefanelli *et al.*, 2022; Zhou and Sun, 2024).

### 2.2 Theoretical background
To provide a theoretical underpinning for our study on SME financing through alternative finance instruments, we draw on the Transaction Cost Economics (TCE) theory, primarily

developed by Williamson (1989). TCE is particularly relevant in understanding the efficiencies of different financial mechanisms, as it focuses on the costs of conducting transactions through the market versus within a firm. This framework helps in examining how alternative financing methods can reduce transaction costs for SMEs, which often face higher costs due to their limited access to traditional capital markets and the complexities involved in obtaining bank financing.

According to TCE, the choice between different financing options can be analysed through the lens of transaction cost minimization, which includes costs related to searching for information, negotiating terms, and monitoring agreements. Alternative finance tools, such as P2P lending and equity crowdfunding, often streamline these processes by leveraging digital platforms to reduce the distance between lenders and borrowers, thereby diminishing the information asymmetry typically encountered in traditional banking relationships. This approach supports the exploration of how technological advancements in finance reduce transaction costs and thereby alter the traditional bank-firm relationships. It also provides a framework to understand why SMEs might prefer alternative finance sources that offer lower transaction costs and more flexible, accessible financial products.

## 3. Fuzzy methodology
This study adopts a stratified implementation of fuzzy methodologies to address the complexities inherent in financial decision-making for SME financing. The chosen approach combines Spherical Fuzzy Entropy, Spherical Fuzzy ARAS, and Spherical Fuzzy TOPSIS methods, which are particularly suited to scenarios characterized by high ambiguity and subjective evaluations in literature (Doumpos and Figueira, 2019; Aydoğdu and Gül, 2022; Gocer and Sener, 2022). The combination of these methods allow for a detailed analysis of the various financial instruments available to SMEs, helping to determine the most suitable options based on multiple criteria such as interest rates, flexibility, risk, and approval times.

The rationale for selecting a fuzzy-based methodology is derived from its ability to handle the uncertainty that accompany financial assessments (Seyfi-Shishavan *et al.*, 2021). Traditional decision-making tools may not adequately capture the subtleties of financial environments where data are not only scarce but also often qualitative in nature. Fuzzy logic provides a framework for quantifying and systematically evaluating this qualitative information, making it possible to integrate expert judgements effectively into the decision matrix (Singh *et al.*, 2018; Venkatesh *et al.*, 2019). By employing these advanced fuzzy methodologies, our study ensures a robust and comprehensive evaluation of the funding alternatives, providing significant clarification on the most effective financing strategies for SMEs.

### 3.1 Spherical Fuzzy Entropy
The use of the entropy measure, an essential mathematical construct for assessing ambiguous information, is a core aspect of the study, offering a means to quantify the obscurity levels (Aydoğdu and Gül, 2022). This entropy method, instrumental in multi-criteria decision-making scenarios MCDA (Doumpos and Figueira, 2019), leverages the principle of information measurement to assign appropriate weights to different criteria (Ma *et al.*, 2023). Our paper implements the entropy technique in conjunction with Spherical fuzzy. This process commences with the collection of expert perspectives. The gathered evaluations are then transformed into fuzzy numbers, guided by the parameters outlined in Table 1. The table describes varying degrees of importance from "Absolutely low importance" to "Absolutely more importance", mapped to Direct Relationship Degree ($\mu$), Indirect Relationship Degree ($v$), and Hesitancy Degree ($\pi$). These include numerical

| | Direct relationship degree ($\mu$) | Indirect relationship degree ($v$) | Hesitancy degree ($\pi$) |
|---|---|---|---|
| 1 - Absolutely low importance | 10 | 90 | 10 |
| 2 - Very low importance | 20 | 80 | 20 |
| 3 - Low importance | 30 | 70 | 30 |
| 4 - Slightly low importance | 40 | 60 | 40 |
| 5 - Equally importance | 50 | 50 | 50 |
| 6 - Slightly more importance | 60 | 40 | 40 |
| 7 - High importance | 70 | 30 | 30 |
| 8 - Very high importance | 80 | 20 | 20 |
| 9 - Absolutely more importance | 90 | 10 | 10 |

**Table 1.**
Variable interpretation guidelines for experts

**Note(s):** In the first column is exhibited the degrees of importance. Follows the scores of the direct relationship, the indirect relationship and finally the hesitancy degree

**Source(s):** Authors' own creation

representations such as a value of 10 for "Absolutely low importance" and up to 90 for "Absolutely more importance", thus enabling the conversion of qualitative expert opinions into quantifiable fuzzy numbers.

A decision matrix ($D$) is generated as the next step in our methodology using the spherical weighted arithmetic mean (SWAM) values obtained in the previous process. This computation is achieved by applying Equations (1) and (2). Equation (1) represents the SWAM of the decision matrix, which essentially computes the average of the derived values by applying the arithmetic mean to the fuzzy numbers. This process involves an intricate combination of product and square-root operations on the Direct Relationship Degree ($\mu$), Indirect Relationship Degree ($v$), and Hesitancy Degree ($\pi$) parameters of each decision value ($D_{Si}$), for all "n" instances. On the other hand, Equation (2) illustrates the decision matrix ($D$) structure, which is a multi-dimensional array consisting of tuples. Each tuple corresponds to a set of Direct Relationship Degree ($\mu$), Indirect Relationship Degree ($v$), and Hesitancy Degree ($\pi$) parameters. The matrix is composed to include all instances (from 1 through "m" and "n") of these parameters.

$$SWAM(D_{S1}, D_{S2}, \ldots, D_{Sn}) = \begin{cases} \left[1 - \prod_{i=i}^{n}\left(1 - \mu_{D_{Si}}^2\right)^{\frac{1}{n}}\right]^{\frac{1}{2}} \\ \\ \prod_{i=i}^{n} v_{D_{Si}}^{\frac{1}{n}} \\ \\ \left[\prod_{i=i}^{n}\left(1 - \mu_{D_{Si}}^2\right)^{\frac{1}{n}} - \prod_{i=i}^{n}\left(1 - \mu_{D_{Si}}^2 - \pi_{D_{Si}}^2\right)^{\frac{1}{n}}\right]^{\frac{1}{2}} \end{cases} \quad (1)$$

$$D = \begin{bmatrix} (\mu_{11}, v_{11}, \pi_{11}) & \cdots & (\mu_{m1}, v_{m1}, \pi_{m1}) \\ \vdots & \ddots & \vdots \\ (\mu_{1n}, v_{1n}, \pi_{1n}) & \cdots & (\mu_{mn}, v_{mn}, \pi_{mn}) \end{bmatrix} \qquad (2)$$

Subsequently, the entropy value ($E$), an integral measure within this methodology, is derived from the decision matrix ($D$) as the next step. This calculation is facilitated through the use of Equation (3). This outlines the process for entropy calculation, which essentially averages the summed results of a set formula for all "n" instances in the decision matrix. The formula embedded within this equation involves both absolute value operations and subtraction, applied to the Direct Relationship Degree ($\mu$), Indirect Relationship Degree ($v$), and Hesitancy Degree ($\pi$) for each ith element of the decision matrix.

$$E = \frac{1}{n} \sum_{i=1}^{n} \left( 1 - \frac{4}{5} \left[ \left| \mu_{ij}^2 - v_{ij}^2 \right| + \left| \pi_{ij}^2 - 0.25 \right| \right] \right) \qquad (3)$$

In addition, the divergence value ($div$), another key parameter within our methodology, is computed using Equation (4). It represents a method for calculating the divergence value for the jth element, a metric that indicates the variation or discrepancy within the data. This computation is achieved by subtracting the corresponding entropy value ($E_j$) from 1. The divergence value essentially provides a measure of the distinctness or uniqueness of each element in the data set, complementing the entropy value's representation of uncertainty.

$$div_j = 1 - E_j \qquad (4)$$

Lastly, the weights (w) of the criteria, a fundamental component of this methodology, are derived using Equation (5). It lays out the process for determining the weight of each criterion. This is done by dividing the divergence value ($div_j$) of the jth element by the sum of all divergence values. The weights represent each criterion's relative importance or influence in the decision matrix. By determining these weights, the methodology provides a systematic and quantitative means to factor in the varying significance of each criterion in the multi-criteria decision-making process. This step completes the mathematical processing of the initial fuzzy evaluations, providing a robust foundation for subsequent analysis.

$$w_j = \frac{div_j}{\sum_{j=1}^{m} div_j} \qquad (5)$$

### 3.2 Spherical fuzzy ARAS
The ARAS method is a robust multi-criteria decision-making methodology that enables the evaluation of different alternatives through expert assessments and contrasts the scores of selected options with the ideal best alternative (Gocer and Sener, 2022). Its simplicity and absence of complex computations make it an advantageous approach (Menekşe and Camgöz Akdağ, 2022). In this study, we incorporate the ARAS method alongside Spherical fuzzy numbers. In this process, we initially gathered expert assessments using the scales from Table 1. Given their qualitative nature, these assessments are subsequently translated into quantifiable fuzzy numbers based on the values provided in the table. Following this, the decision matrix ($D$) is constructed by averaging these expert opinions, facilitated by Equation (1). The next step involves the formation of a weighted decision matrix (X), which is derived from the decision matrix ($D$) and criterion weights ($w$) through multiplication, as depicted in Equation (6). Equation (7), on the other hand, illustrates an operation performed on

each element ($D_S$) in the decision matrix, where "$\lambda$" is a parameter. This operation includes square root, power, and subtraction functions applied on the Direct Relationship Degree ($\mu$), Indirect Relationship Degree ($v$), and Hesitancy Degree ($\pi$) for each element.

$$X = w.D \tag{6}$$

$$\lambda D_s = \left\{ \left( 1 - \left( 1 - \mu_{D_S}^2 \right)^\lambda \right)^{\frac{1}{2}}, v_{D_S}^\lambda, \left( \left( 1 - \mu_{D_S}^2 \right) - \left( 1 - \mu_{D_S}^2 - \pi_{D_S}^2 \right)^\lambda \right)^2 \right\} \tag{7}$$

Subsequently, we proceed to calculate the optimal values for each criterion. Comparing two numbers is performed over score and accuracy values when dealing with spherical fuzzy numbers. Should the score values be equal, the number with the higher accuracy value is deemed more significant (Gadekar *et al.*, 2022). This process is facilitated through the implementation of Equations (8) and (9). Equation (8) calculates the score of each criterion, utilizing a formula that squares and subtracts the Hesitancy Degree ($\pi$) from both the Direct Relationship Degree ($\mu$) and the Indirect Relationship Degree ($v$). In contrast, Equation (9) calculates the accuracy of each criterion. This is achieved by squaring each of the three Degrees - $\mu$, $v$, and $\pi$ - and then summing up these squared values. By applying these equations, we effectively ascertain the most favourable values for each criterion, enhancing the precision and reliability of the decision-making process.

$$Score = (\mu - \pi)^2 - (v - \pi)^2 \tag{8}$$

$$Accuracy = \mu^2 + v^2 + \pi^2 \tag{9}$$

After determining optimal values for each criterion, the spherical fuzzy optimality function ($S_i$) is computed. This calculation involves summating the optimal values and the alternatives, considering the individual criteria. Equation (10) provides the formula to calculate the spherical fuzzy optimality function. It consists of the summation across "m" criteria of the Direct Relationship Degree ($\mu$), Indirect Relationship Degree ($v$), and Hesitancy Degree ($\pi$) for each criterion and its alternatives (Seyfi-Shishavan *et al.*, 2021). This aggregation into the spherical fuzzy optimality function marks a significant step within the methodology, merging the previous computations to evaluate the alternatives based on all the criteria comprehensively.

$$S_{Si} = \sum_{i=1}^{m} [(\mu + v + \pi) + (\mu_2 + v_2 + \pi_2) + \ldots + (\mu_m + v_m + \pi_m)] \tag{10}$$

Following the calculation of the spherical fuzzy optimality function ($S_i$), we apply the previously defined score and accuracy functions to perform a defuzzification process on these values, resulting in the calculation of $S_i$ values. $S_O$ represents the defuzzified value derived from the summation of all optimal values. The final step in this methodology involves the use of Equation (11), wherein the sum of the alternatives is divided by the sum of the optimal values to compute the utility degree ($K_i$). This utility degree serves as a summary statistic of the alternatives' performance relative to the optimal values, thereby providing a comprehensive and quantitative basis for decision-making.

$$K_i = \frac{S_i}{S_0} \tag{11}$$

*3.3 Spherical fuzzy TOPSIS*
In addition to the ARAS method, the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) is utilized to rank the various alternatives (Singh *et al.*, 2018;

Venkatesh *et al.*, 2019). To pursue the scope of the study, we integrate the TOPSIS technique with Spherical fuzzy sets. Initially, expert opinions are solicited, relying on the scales presented in Table 1. Following this, we create the decision matrix ($D$) by averaging these expert opinions, a process facilitated by Equation (1). As the next step, the decision matrix is multiplied by the criterion weights ($w$), yielding the weighted decision matrix ($X$). This operation is guided by Equations (6) and (7). Subsequently, the ideal negative ($X$) and ideally positive ($X^*$) optimal values are computed for each criterion. Equations (12) and (13) aid in this calculation process. Equation (12) details the computation for the ideal positive solution ($S^*$), which selects the maximum score value amongst the criterion scores ($C_j$) in the weighted decision matrix ($X$). Equation (13), on the other hand, describes the process of determining the ideal negative solution ($S^-$), selecting the minimum score amongst the criterion scores in the weighted decision matrix.

$$S^* = \left\{ C_j, \genfrac{}{}{0pt}{}{max}{i} < Score(C_j(s_{iw})) \rangle | j = 1, 2, \ldots, n| \right\} \tag{12}$$

$$S^- = \left\{ C_j, \genfrac{}{}{0pt}{}{min}{i} < Score(C_j(s_{iw})) \rangle | j = 1, 2, \ldots, n| \right\} \tag{13}$$

Following the computation of the ideal negative and positive values, the next phase involves determining the distances of each alternative from these ideal values. This consists in employing the normalized Euclidean distance formula, as expressed in Equations (14) and (15). Equation (14) outlines the method to calculate the distance from each alternative ($S_i$) to the negative ideal value ($S^-$). It applies the square root to the average of the squared differences between each criterion's Direct Relationship Degree ($\mu$), Indirect Relationship Degree ($v$), and Hesitancy Degree ($\pi$) of each alternative and the corresponding values of the negative ideal. Similarly, Equation (15) provides the formula to compute the distance from each alternative ($S_i$) to the positive ideal value ($S^*$). Similar to Equation (14), it utilizes the square root of the average of the squared differences between each criterion's $\mu$, $v$, and $\pi$ of each alternative and the corresponding values of the positive ideal.

$$D(S_i, S^-) = \sqrt{\frac{1}{2n} \sum_{i=1}^{n} \left( \left( \mu_{X_i} - \mu_{X^-} \right)^2 + (\mu_v - v_{X^-})^2 + \left( \pi_{X_i} - \pi_{X^-} \right)^2 \right)} \tag{14}$$

$$D(S_i, S^*) = \sqrt{\frac{1}{2n} \sum_{i=1}^{n} \left( \left( \mu_{X_i} - \mu_{X^*} \right)^2 + (\mu_v - v_{X^*})^2 + \left( \pi_{X_i} - \pi_{X^*} \right)^2 \right)} \tag{15}$$

In the final stage of this methodology, the classical closeness ratio ($C$) is calculated, employing Equation (16). It provides the formula to calculate the closeness ratio for each alternative ($X_i$). It divides the distance from each alternative to the negative ideal ($D(S_i, S^-)$) by the sum of the distance from each alternative to both the negative and positive ideals ($D(S_i, S^-) + D(S_i, S^*)$).

$$C(X_i) = \frac{D(S_i, S^-)}{D(S_i, S^-) + D(S_i, S^*)} \tag{16}$$

## 4. Results
### 4.1 The definition of the problem
The primary objective of this research is to identify and rank the most prevalent alternative finance instruments used for funding SMEs. A fuzzy decision-making model is implemented

to achieve this goal, merging the Entropy and ARAS techniques with Spherical fuzzy sets. The introduction of this model examines alternative funding approaches beyond conventional credit channel (bank credit). Furthermore, the Spherical fuzzy Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) is integrated into the model to effectively rank these funding alternatives, thereby allowing an assessment of the validity of the results.

### 4.2 The details of criteria and funding alternatives

This study employs multiple criteria that hold distinct significance in the decision-making process regarding alternative SME funding (Table 2). These determinants have been identified through an extensive literature review, and each is supported by previous studies that underscore their relevance in the context of SME financing. We provide a detailed description of all criteria implemented in our analysis. (1) *Interest Rate*, as a first criterion, refers to the borrowing cost or, alternatively, the return an investor expects from a specific investment. This determinant significantly influences the affordability of alternative finance for SMEs (Cressy and Olofsson, 1997; De Blasio *et al.*, 2018). (2) *Flexibility* is another crucial factor in the firm's assessment process of different funding solutions. It indicates the adaptability of the financial instrument. It reflects how well the terms and conditions of the funding option, such as repayment schedules or interest rates, can satisfy SMEs' needs (Levy and Powell, 1998; Whyman and Petrescu, 2015). (3) *Accessibility* is an analysis criterion that indicates the level of easiness with which SMEs can secure a financial instrument. It covers the financial tool's availability, its application process simplicity, and its eligibility criteria's inclusiveness (García-Teruel and Martínez-Solano, 2008). (4) *Advisory support*, as an additional criterion of our analysis, includes different customize benefits and/or additional services offered by funder players. These services may include mentorship, guidance, networking opportunities, or further resources that can significantly improve the effectiveness of the financial instrument (Garcia-Tabuenca and Crespo-Espert, 2010; Nakku *et al.*, 2020). (5) *Riskiness* is a determinant that refers to the level of uncertainty or potential financial loss associated with the funding instrument chosen by SMEs. It underscores the unpredictability that could characterize each available funding method (Sohn and Jeon, 2010; Luo *et al.*, 2016). The last criterion is the (6) *Approval Time*, which indicates the average timeframe for approval of a funding request. This determinant is critical in the firms' evaluation processes because it affects the speed of the funding practices (Chen *et al.*, 2009; Mustafa and Yaakub, 2018).

The analysis conducted in this study involves a range of alternatives concerning SME funding, each of which is supported by existing literature sources (Table 3). The former is *Equity Crowdfunding*, an alternative channel in which funding is sourced from the "crowd". In this funding process, each individual provides a small amount in exchange for equity

| Determinants | Supported literature |
|---|---|
| *Interest rate* | Cressy and Olofsson (1997), De Blasio *et al.* (2018) |
| *Flexibility* | Levy and Powell (1998), Whyman and Petrescu (2015) |
| *Accessibility* | García-Teruel and Martínez-Solano (2008) |
| *Advisory support* | Garcia-Tabuenca and Crespo-Espert (2010), Nakku *et al.* (2020) |
| *Riskiness* | Sohn and Jeon (2010), Luo *et al.* (2016) |
| *Approval time* | Chen *et al.* (2009), Mustafa and Yaakub (2018) |

**Note(s):** For each criteria listed in determinants follows the reference literature
**Source(s):** Authors' own creation

**Table 2.**
Selected criteria and reference literature

| Alternatives | Supported literature |
|---|---|
| *Equity crowdfunding* | Hornuf and Schwienbacher (2017), Eldridge *et al*. (2021), Tiberius and Hauptmeijer (2021) |
| *Peer-to-peer (P2P) lending* | Gao *et al*. (2018), Chen *et al*. (2020) |
| *Business angels* | Mason *et al*. (2017), Croce *et al*. (2021) |
| *Venture capital* | Creddy and Olofsson (1997), Berger and Schaeck (2011) |
| *Factoring* | Klapper (2006), Mol-Gómez-Vázquez *et al*. (2018) |
| *Leasing* | Lasfer and Levis (1998), Cosci *et al*. (2015) |
| *Private equity* | Bertoni *et al*. (2013), Paglia and Harjoto (2014), Sinyard *et al*. (2020) |
| *Bonds* | Mietzner *et al*. (2018) |
| *Sovereign funds* | Ferreira and Saridakis (2017) |
| *Traditional loans* | Riding *et al*. (2007), Ono and Uesugi (2009), Grunert and Nordern (2012), Bertoni *et al*. (2023) |

**Note(s):** For each alternative finance instrument listed follows the reference literature
**Source(s):** Authors' own creation

Table 3.
Selected alternatives
and reference literature

shares in the "*borrower*" SME. This funding method promotes engagement and strategic interaction with potential customers ("crowd-borrowers") and investors ("crowd-lenders") (Hornuf and Schwienbacher, 2017; Eldridge *et al.*, 2021; Tiberius and Hauptmeijer, 2021). The second one, *Peer-to-Peer (P2P) Lending,* refers to a funding process offered through digital platforms (Stefanelli *et al.*, 2022). Using a digital environment, such as an online portal, multiple investors (private or institutional investors) could lend money to businesses without the intermediation of a traditional financial institution. This financing channel has gained growing interest due to its simplicity and the direct link created between crowd-lenders and crowd-borrowers (Gao *et al.*, 2018; Chen *et al.*, 2020). The third alternative is *Business Angel,* which is typically represented by high-net-worth individuals who provide capital for a business start-up, usually in exchange for convertible debt or ownership equity. The business angels' investments often offer both financial and strategic support to SMEs (Mason *et al.*, 2017; Croce *et al.*, 2021). Our analysis also includes *Venture Capital*, as a form of private equity and a type of financing provided by firms or funds to start-ups, early-stage, and emerging companies that could be characterised by high potential growth (Cressy and Olofsson, 1997; Berger and Schaeck, 2011). The fifth funding alternative is *Factoring*. It is a type of financial transaction where a business sells its accounts receivables to a third party at a discount. This instrument could also help businesses to improve their cashflows (Klapper, 2006; Mol-Gómez-Vázquez *et al.*, 2018). The sixth is *Leasing* which is characterised by an agreement where a leasing company (or lessor), provides an asset for use to a lessee over a predetermined period in exchange for recurring payments. It is an additional funding source that acts without diluting ownership (Lasfer and Levis, 1998; Cosci *et al.*, 2015). The seventh alternative is *Private Equity;* it refers to capital investment made into companies that are not publicly traded. Generally, Private equity firms, high-net-worth individuals, or institutional investors run this type of strategic and riskiness investments (Bertoni *et al.*, 2013; Paglia and Harjoto, 2014; Sinyard *et al.*, 2020). We also considered the *Bonds* as a valuable alternative. They are a form of long-term debt in which the issuer undertakes to pay the principal and the additional interest (also known as the coupon) on a specified date or dates. This financing method has gained popularity amongst SMEs due to its structured repayment schedule and relatively lower interest rates (Mietzner *et al.*, 2018). The ninth alternative involves *Sovereign Funds,* which refer to state-owned investment funds, typically funded by revenue generated from a country's reserves. These funds invest globally in real estate, stocks, bonds, and other types of investments (Ferreira and Saridakis, 2017). Finally, the last alternative is the *Traditional*

*Loans.* These represent the well-known method of financing provided by banking institutions or other traditional lenders. Despite their familiarity, this funding method is characterized by a rigorous approval process and stringent requirements that could hamper their accessibility (Riding *et al.*, 2007; Ono and Uesugi, 2009; Grunert and Norden, 2012; Bertoni *et al.*, 2023).

### 4.3 Weighting the indicators by spherical fuzzy entropy

In our analysis, firstly, we assembled a team of experts consisting of three decision-makers (Table 4). These experts are academics renowned for their extensive research in small-medium enterprises, alternative finance, and bank lending. The understandings gathered from these experts are averaged using the first and second steps. The outcomes of this process are presented in Table 4, in which we illustrate the averaged views of the expert panel, broken down by the criteria of interest rate, flexibility, accessibility, support, riskiness, and approval time. Each criterion is further detailed by the spherical fuzzy numbers of components "$\mu$" (membership), "$v$" (non-membership), and "$\pi$" (hesitation).

Utilizing Equation (3), entropy values are derived from the decision matrix (D). Subsequently, divergence values and weights are computed. The findings from these calculations are presented in Table 5.

The entropy values depict the amount of inherent randomness, or unpredictability, within each criterion. A higher entropy value signifies a greater degree of randomness or variability in the data, which could indicate more complex expert opinions. Divergence values are calculated as the difference between unity and the entropy value for each criterion. They essentially illustrate the amount of useful or distinct information present in each criterion. Higher divergence values suggest that the criterion offers substantial information. Weights are calculated from the divergence values, denoting each criterion's relative importance in the decision-making process. They essentially provide a ranking of the criteria based on their significance in the model.

### 4.4 Ranking the alternatives by spherical fuzzy ARAS

The decision-making process integrates the expert opinions, as presented in Table 2, with the derived weights from Equation (5). This integration gives rise to the weighted decision matrix (*X*), as computed by deploying Equations (6) and (7), the details of which are outlined in Table 4. Subsequently, the score and accuracy values are calculated with reference to Equations (8) and (9), utilizing the values exhibited in Table 5. Given that all criteria are of benefit type, the optimal value is determined as the highest value. These identified optimal values are encapsulated in Table 6, which features the weighted decision matrix.

The Spherical fuzzy optimality function values are computed using Equation (10). Subsequently, these values undertake a defuzzification process, as presented in Table 7.

In response to RQ1, Table 8 and Appendix 1 show the ranking of alternative financial instruments for SMEs, calculated using the abovementioned TOPSIS method. *Traditional Loans* top the ranking with a score of 0.55. As a familiar and reliable method, SMEs often turn to these loans as their primary source of finance. Its accessibility and predictable terms make it an attractive option. However, strict eligibility criteria and collateral requirements can be a challenge for some SMEs.

The second-ranked choice, Peer-to-Peer (P2P) Lending, scores 0.51. This method used digital platforms to match online SMEs with lenders. This process provides a more efficient and streamlined lending offering, which could mean faster access to capital with fewer bureaucratic barriers for SMEs. *Venture Capital Funds* ranks third with a score of 0.50. This funding source can provide financial resources for growth-oriented SMEs; however, it often requires giving up a share of ownership. Using this funding alternative, SMEs should carefully consider the potential impact on decision-making and company direction. *Bond*

| | Interest rate | | | Flexibility | | | Accessibility | | | Support | | | Riskiness | | | Approval time | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\mu$ | $v$ | $\pi$ | $\mu$ | $v$ | $\pi$ | $\mu$ | $v$ | $\pi$ | $\mu$ | $v$ | $\pi$ | $\mu$ | $v$ | $\pi$ | $\mu$ | $v$ | $\pi$ |
| *Equity crowdfunding* | 0.125 | 0.165 | 0.205 | 0.111 | 0.131 | 0.141 | 0.069 | 0.079 | 0.129 | 0.107 | 0.127 | 0.167 | 0.129 | 0.149 | 0.159 | 0.059 | 0.109 | 0.119 |
| *Peer-to-peer (P2P) lending* | 0.094 | 0.144 | 0.174 | 0.148 | 0.178 | 0.198 | 0.103 | 0.133 | 0.143 | 0.071 | 0.101 | 0.141 | 0.097 | 0.107 | 0.147 | 0.059 | 0.069 | 0.079 |
| *Business angels* | 0.063 | 0.103 | 0.093 | 0.074 | 0.104 | 0.054 | 0.138 | 0.158 | 0.128 | 0.143 | 0.173 | 0.123 | 0.097 | 0.127 | 0.077 | 0.059 | 0.069 | 0.029 |
| *Venture capital* | 0.094 | 0.084 | 0.054 | 0.111 | 0.081 | 0.051 | 0.103 | 0.073 | 0.053 | 0.107 | 0.097 | 0.067 | 0.129 | 0.109 | 0.089 | 0.059 | 0.049 | 0.019 |
| *Factoring* | 0.125 | 0.115 | 0.105 | 0.074 | 0.064 | 0.034 | 0.103 | 0.093 | 0.063 | 0.071 | 0.041 | 0.011 | 0.097 | 0.067 | 0.047 | 0.176 | 0.166 | 0.156 |
| *Leasing* | 0.063 | 0.053 | 0.023 | 0.148 | 0.138 | 0.108 | 0.103 | 0.073 | 0.063 | 0.071 | 0.041 | 0.011 | 0.065 | 0.045 | 0.035 | 0.118 | 0.098 | 0.088 |
| *Private equity* | 0.094 | 0.064 | 0.054 | 0.074 | 0.044 | 0.034 | 0.069 | 0.059 | 0.049 | 0.143 | 0.113 | 0.093 | 0.129 | 0.109 | 0.089 | 0.088 | 0.078 | 0.058 |
| *Bonds* | 0.125 | 0.165 | 0.185 | 0.074 | 0.084 | 0.104 | 0.069 | 0.119 | 0.149 | 0.071 | 0.111 | 0.151 | 0.097 | 0.117 | 0.147 | 0.147 | 0.177 | 0.187 |
| *Sovereign funds* | 0.063 | 0.083 | 0.063 | 0.074 | 0.155 | 0.125 | 0.138 | 0.155 | 0.135 | 0.107 | 0.155 | 0.145 | 0.065 | 0.155 | 0.145 | 0.147 | 0.155 | 0.145 |
| *Traditional loans (Benchmark)* | 0.156 | 0.356 | 0.476 | 0.111 | 0.301 | 0.341 | 0.103 | 0.133 | 0.223 | 0.107 | 0.167 | 0.367 | 0.097 | 0.177 | 0.197 | 0.088 | 0.198 | 0.298 |

**Note(s):** In table is represented the decision matrix for each fuzzy determinant

**Source(s):** Authors' own creation

**Table 4.**
Decision or
performance matrix

*Issuance*, with a score of 0.48, ranks fourth. Although more commonly associated with larger corporations, issuing bonds can be a viable method for SMEs to raise capital.

This channel can provide significant funding without ownership dilution, but it requires a robust firm's financial structure to manage the repayment obligations properly. *Factoring* ranks fifth with a score of 0.44. For SMEs with substantial receivables, factoring can rapidly provide cashflows to firms. However, it's crucial to assess the cost and the impact of factoring on customer relationships. *Leasing* alternative, scoring 0.43, ranks sixth in the overall classification. This provides a viable method for SMEs to gain access to necessary equipment or property without incurring substantial upfront costs. The seventh position is occupied by *Equity Crowdfunding*, scoring 0.42. This funding option allows a broad base of investors ("crowd-investors") to fund SMEs. It can be valuable for SMEs to raise funds and validate business ideas. However, it is heavily dependent on the ability to attract investors. *Private Equity* ranks eighth with a score of 0.42. This type of funding can provide a significant influx of capital for SMEs looking to scale. However, like venture capital, it often involves relinquishing some control. Lastly, *Sovereign Funds* and *Business Angels*, with a score of 0.412 and 0.397, respectively, take the ninth and tenth positions in the overall classification. While these sources can provide substantial funding to firms, they may come with specific expectations or conditions and may not be as readily accessible to most SMEs.

In conclusion, while *Traditional Loans* (the benchmark alternative) remain the most preferred option according to the TOPSIS ranking method, other funding alternatives present different benefits and potential challenges. From these perspectives, the analysis shows how SMEs should carefully identify and assess their specific needs, circumstances, and strategic goals when choosing among these options.

### 4.5 Making comparative evaluation by spherical fuzzy TOPSIS

Finally, in this proposed model, the funding alternatives are also ranked by implementing the Spherical Fuzzy TOPSIS method. The expert opinions in Table 2 and the weights obtained from Equation (5) have been considered. The weighted decision matrix (X) is obtained by using the equations (6) and (7). Using the values provided in Table 6, equality (8) and (9) and the score and accuracy values are calculated. *Negative* and *positive ideal solutions* are calculated using equations (12) and (13). The values obtained are presented in Table 9.

We computed the distances to both the positive and negative ideal solutions (denoted by $D(X, X-)$ and $D(X, X+)$), using the formulae in Equations (14) and (15). Furthermore, the closeness ratio, a critical metric in TOPSIS used to rank alternatives, was calculated based on equation (16).

Our analysis suggests that P2P Lending is the most preferred financial instrument after traditional loans, with a closeness ratio of 0.7916 (Table 10). This indicates a high alignment of P2P Lending with the ideal financial alternative, meaning smaller distances to the positive ideal solution and larger distances to the negative ideal one. Similarly, both

|  | Interest rate | Flexibility | Accessibility | Support | Riskiness | Approval time |
|---|---|---|---|---|---|---|
| *Entropy values* | 0.4734 | 0.6594 | 0.4975 | 0.486 | 0.454 | 0.5157 |
| *Divergence values* | 0.4798 | 0.4318 | 0.5137 | 0.3743 | 0.4936 | 0.4402 |
| *Weights* | 0.2458 | 0.0403 | 0.1936 | 0.1467 | 0.1984 | 0.1752 |

**Table 5.**
Entropy, divergence and weights matrix

**Note(s):** In table is represented for each criteria the entropy values, divergence values and weights
**Source(s):** Authors' own creation

| | Interest rate | | | Flexibility | | | Accessibility | | | Support | | | Riskiness | | | Approval time | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mu | v | k | mu | v | k | mu | v | k | mu | v | k | mu | v | k | mu | v | k |
| *Equity crowdfunding* | 0.031 | 0.033 | 0.038 | 0.004 | 0.005 | 0.006 | 0.013 | 0.015 | 0.017 | 0.016 | 0.020 | 0.026 | 0.026 | 0.030 | 0.036 | 0.010 | 0.014 | 0.021 |
| *Peer-to-peer (P2P) lending* | 0.023 | 0.030 | 0.035 | 0.006 | 0.008 | 0.009 | 0.020 | 0.024 | 0.026 | 0.010 | 0.015 | 0.018 | 0.019 | 0.023 | 0.033 | 0.010 | 0.016 | 0.017 |
| *Business angels* | 0.015 | 0.028 | 0.025 | 0.003 | 0.004 | 0.002 | 0.027 | 0.034 | 0.031 | 0.021 | 0.024 | 0.021 | 0.019 | 0.023 | 0.021 | 0.010 | 0.017 | 0.009 |
| *Venture capital* | 0.023 | 0.018 | 0.013 | 0.004 | 0.003 | 0.002 | 0.020 | 0.016 | 0.012 | 0.016 | 0.014 | 0.013 | 0.026 | 0.024 | 0.020 | 0.010 | 0.007 | 0.005 |
| *Factoring* | 0.031 | 0.026 | 0.021 | 0.003 | 0.002 | 0.002 | 0.020 | 0.014 | 0.010 | 0.010 | 0.009 | 0.006 | 0.019 | 0.013 | 0.011 | 0.031 | 0.026 | 0.024 |
| *Leasing* | 0.015 | 0.008 | 0.006 | 0.006 | 0.006 | 0.005 | 0.020 | 0.016 | 0.012 | 0.010 | 0.006 | 0.005 | 0.013 | 0.007 | 0.001 | 0.021 | 0.019 | 0.015 |
| *Private equity* | 0.023 | 0.016 | 0.008 | 0.003 | 0.002 | 0.001 | 0.013 | 0.008 | 0.002 | 0.021 | 0.018 | 0.017 | 0.026 | 0.022 | 0.018 | 0.015 | 0.014 | 0.010 |
| *Bonds* | 0.031 | 0.036 | 0.041 | 0.003 | 0.004 | 0.005 | 0.013 | 0.023 | 0.025 | 0.010 | 0.016 | 0.022 | 0.019 | 0.023 | 0.027 | 0.026 | 0.035 | 0.036 |
| *Sovereign funds* | 0.015 | 0.018 | 0.013 | 0.003 | 0.006 | 0.006 | 0.027 | 0.030 | 0.028 | 0.016 | 0.023 | 0.021 | 0.013 | 0.031 | 0.027 | 0.026 | 0.027 | 0.022 |
| *Traditional loans (Benchmark)* | 0.038 | 0.068 | 0.110 | 0.004 | 0.005 | 0.006 | 0.020 | 0.022 | 0.051 | 0.016 | 0.020 | 0.030 | 0.019 | 0.033 | 0.065 | 0.015 | 0.026 | 0.033 |

**Note(s):** In table is represented the weighted decision matrix for each fuzzy determinant

**Source(s):** Authors' own creation

Table 6.
Weighted decision
matrix

| | mu | v | k | Score | Accuracy |
|---|---|---|---|---|---|
| *Equity crowdfunding* | 0.614 | 0.430 | 0.353 | 0.018 | 0.669 |
| *Peer-to-peer (P2P) lending* | 0.572 | 0.362 | 0.287 | 0.012 | 0.628 |
| *Business angels* | 0.573 | 0.403 | 0.194 | −0.004 | 0.681 |
| *Venture capital* | 0.603 | 0.133 | 0.124 | 0.004 | 0.529 |
| *Factoring* | 0.647 | 0.107 | 0.142 | 0.009 | 0.630 |
| *Leasing* | 0.568 | 0.218 | 0.186 | 0.013 | 0.631 |
| *Private equity* | 0.597 | 0.357 | 0.209 | 0.008 | 0.668 |
| *Bonds* | 0.583 | 0.353 | 0.321 | 0.020 | 0.716 |
| *Sovereign funds* | 0.593 | 0.458 | 0.239 | 0.007 | 0.600 |
| *Traditional loans (Benchmark)* | 0.663 | 0.493 | 0.374 | 0.153 | 0.635 |

**Table 7.**
Spherical fuzzy and
defuzzified Si values

**Note(s):** In table is represented the defuzzified $S_i$ Values
**Source(s):** Authors' own creation

| Alternatives | Score |
|---|---|
| *Traditional loans (Benchmark)* | 0.5497 |
| *Peer-to-peer (P2P) lending* | 0.5076 |
| *Venture capital funds* | 0.5023 |
| *Bond issuance* | 0.4842 |
| *Factoring* | 0.4423 |
| *Leasing* | 0.4279 |
| *Equity crowdfunding* | 0.4221 |
| *Private equity* | 0.4183 |
| *Sovereign funds* | 0.4120 |
| *Business angels* | 0.3969 |

**Table 8.**
Final funding
alternatives ranked
by Ki

**Note(s):** In table is represented the final ranking of financing alternatives
**Source(s):** Authors' own creation

Venture Capital Funds (with a ratio of 0.7552) and Bond Issuance (0.7345) show effective performance. Conversely, Business Angels (0.2646) and Sovereign Funds (0.3535) lag in their effectiveness.

Table 11 presents a comparative analysis of the ranking results obtained through two different multi-criteria decision-making methods: Spherical Fuzzy ARAS (Additive Ratio Assessment) and Spherical Fuzzy TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). The table compares the alternatives' scores and their respective rankings as obtained by the two techniques. In terms of their ranking, both methodologies gave similar results.

The order of the alternatives from highest to lowest rank remains the same for both the implemented methods: (1) *Traditional Loans (Benchmark),* (2) *Peer-to-peer (P2P) lending,* (3) *Venture Capital Funds,* (4) *Bond Issuance,* (5) *Factoring,* (6) *Leasing,* (7) *Equity Crowdfunding,* (8) *Private Equity,* (9) *Sovereign Funds, and finally,* (10) *Business Angels.* This suggests a robust consensus between these two distinct decision-making methods, enhancing the consistency of our results. Looking at the scores obtained, both methods have given similar values. However, Spherical Fuzzy ARAS provides slightly higher scores than Spherical Fuzzy TOPSIS for each alternative. Despite this difference, the relative order of the alternatives remains consistent between the two methods. This shows that while each method may weigh certain aspects differently, the overall results are consistent.

| | Interest rate | | | Flexibility | | | Accessibility | | | Support | | | Riskiness | | | Approval time | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mu | v | k | mu | v | k | mu | v | k | mu | v | k | mu | v | k | mu | v | k |
| Positive ideal solution (S+) | 0.038 | 0.068 | 0.110 | 0.006 | 0.008 | 0.009 | 0.027 | 0.034 | 0.051 | 0.021 | 0.024 | 0.030 | 0.026 | 0.033 | 0.065 | 0.031 | 0.035 | 0.036 |
| Negative ideal solution (S−) | 0.015 | 0.008 | 0.006 | 0.003 | 0.002 | 0.001 | 0.013 | 0.008 | 0.002 | 0.010 | 0.006 | 0.005 | 0.013 | 0.007 | 0.001 | 0.010 | 0.007 | 0.005 |

**Note(s):** In table is represented the positive and negative ideal solution
**Source(s):** Authors' own creation

Table 9.
Positive and negative
ideal solutions

| Alternatives | D(X,X-) | D(X,X+) | Closeness ratio |
|---|---|---|---|
| Bond issuance | 0.2107 | 0.0762 | 0.7345 |
| Business angels | 0.2419 | 0.6722 | 0.2646 |
| Equity crowdfunding | 0.2258 | 0.2096 | 0.5185 |
| Factoring | 0.2149 | 0.1059 | 0.6700 |
| Leasing | 0.2171 | 0.1398 | 0.6083 |
| Peer-to-peer (P2P) lending | 0.1948 | 0.0513 | 0.7916 |
| Private equity | 0.2348 | 0.2872 | 0.4498 |
| Sovereign funds | 0.2371 | 0.4337 | 0.3535 |
| Traditional loans (Benchmark) | 0.1910 | 0.0000 | 1.0000 |
| Venture capital funds | 0.2026 | 0.0657 | 0.7552 |

**Note(s):** In table is represented the distance to positive and negative ideal solutions
**Source(s):** Authors' own creation

**Table 10.**
Distances to positive
and negative ideal
solutions

| Spherical fuzzy ARAS<br>Alternative | Score | Rank | Score | Rank | Spherical fuzzy TOPSIS<br>Alternative |
|---|---|---|---|---|---|
| Traditional loans (Benchmark) | 0.5497 | 1 | 0.5269 | 1 | Traditional Loans (Benchmark) |
| Peer-to-peer (P2P) lending | 0.5076 | 2 | 0.4966 | 2 | Peer-to-Peer (P2P) Lending |
| Venture capital funds | 0.5023 | 3 | 0.4870 | 3 | Venture Capital Funds |
| Bond issuance | 0.4842 | 4 | 0.4614 | 4 | Bond Issuance |
| Factoring | 0.4423 | 5 | 0.4152 | 5 | Factoring |
| Leasing | 0.4279 | 6 | 0.4031 | 6 | Leasing |
| Equity crowdfunding | 0.4221 | 7 | 0.3973 | 7 | Equity Crowdfunding |
| Private equity | 0.4183 | 8 | 0.3942 | 8 | Private Equity |
| Sovereign funds | 0.4120 | 9 | 0.3928 | 9 | Sovereign Funds |
| Business angels | 0.3969 | 10 | 0.3769 | 10 | Business Angels |

**Note(s):** In table is exhibited the comparison of ranking between Spherical Fuzzy ARAS and Spherical Fuzzy TOPSIS
**Source(s):** Authors' own creation

**Table 11.**
Comparative ranking
results obtained by
Spherical fuzzy
TOPSIS

*4.6 Discerning SMEs funding needs scenario*
In this study, we run the Spherical Fuzzy ARAS method to understand how SMEs could meet their financial needs. A deeper level of our analysis aims to examine the main determinants influencing the choice of a specific financing instrument/channel able to satify SMEs' contingent funding needs.

To pursue this objective, experts have determined the most relevant criteria for each primary SMEs funding need: (1) *new investment*; (2) *liquidity needs*; (3) *debt restructuring* (Appendix 2). They suggest that *interest rate* impacts new investments, liquidity needs, and debt restructuring. *Flexibility* mainly affects debt restructuring funding objective. *Accessibility* is critical for liquidity needs, while *advisory support* influences new investments and debt restructuring. In addition, *Riskiness* primarily affects new firms' investment objectives, while approval time plays a vital role in satisfying liquidity needs.

In response to RQ2, Table 12 exhibits the Spherical Fuzzy ARAS ranking scores obtained, which reflect the suitability of various funding sources to address SMEs' financial requirements. These requirements include new investments, liquidity needs, and debt restructuring.

For *new investment* objective, the alternative of traditional loans scores the highest with a value of 0.581. This best performance can be attributed to the generally lower interest rates,

| Criteria | New investment | SME funding needs Liquidity needs | Debt restructuring |
|---|---|---|---|
| Interest rate | x | x | x |
| Flexibility | | | x |
| Accessibility | | x | |
| Advisory support | x | | x |
| Riskiness | x | | |
| Approval time | | x | |

| Spherical ARAS Ranking Score | | Spherical ARAS Ranking Score | | Spherical ARAS Ranking Score | |
|---|---|---|---|---|---|
| Traditional loans (Benchmark) | 0.5813 | Traditional Loans (Benchmark) | 0.6417 | Traditional Loans (Benchmark) | 0.6495 |
| Leasing | 0.5585 | Peer-to-Peer (P2P) Lending | 0.6308 | Peer-to-Peer (P2P) Lending | 0.5904 |
| Equity crowdfunding | 0.5496 | Equity Crowdfunding | 0.6216 | Venture Capital Funds | 0.5168 |
| Factoring | 0.5473 | Sovereign Funds or Development | 0.5642 | Sovereign Funds or Development | 0.5083 |
| Venture capital Funds | 0.5398 | Factoring | 0.5614 | Factoring | 0.4998 |
| Business angels | 0.5292 | Venture Capital Funds | 0.5585 | Equity Crowdfunding | 0.4759 |
| Sovereign funds or development | 0.5292 | Business Angels | 0.5289 | Business Angels | 0.4757 |
| Peer-to-peer (P2P) lending | 0.5232 | Bond Issuance | 0.5264 | Leasing | 0.4750 |
| Bond issuance | 0.5227 | Leasing | 0.5159 | Bond Issuance | 0.4673 |
| Private equity | 0.5021 | Private Equity | 0.4874 | Private Equity | 0.4436 |

**Note(s):** In table is represented the final ranking of alternatives for each SME funding scenario
**Source(s):** Authors' own creation

Table 12.
SME funding needs and funding alternatives with spherical Aras ranking

the known risk factors, and the potentially faster approval times that characterize this funding instrument. As a result, traditional loans turn out to be a more favourable option for new investment needs, especially in the case where businesses need affordable and predictable funding. Following traditional loans, *Leasing* scored 0.559; this result implies its efficiency in providing assets for business expansion. *Equity crowdfunding*, with a score of 0.550, remarks this modern funding source's growing adoption and effectiveness in supporting new investments, especially for start-ups and businesses in innovative (e.g. digital or technological) sectors.

In terms of addressing *Liquidity needs*, traditional loans again take the top position with a score of 0.642. The high score of traditional loans highlights their accessibility and relatively quicker approval times, which is a crucial element for businesses facing immediate liquidity needs. *Peer-to-peer (P2P) Lending* and *Equity Crowdfunding* come next in the order of preferences, scoring 0.631 and 0.622, respectively. Their high scores indicate quick disbursement and a relatively less stringent approval process, making them viable alternatives to traditional loans for short-term funding needs.

Concerning *Debt restructuring* needs, our analysis reveals that traditional loans preserve their dominance with a score of 0.650. This rank reflects the instrument flexibility and the potential for advisory support to help businesses manage and reduce their debts effectively. *Peer-to-peer (P2P) Lending,* following with a score of 0.590, shows its increasing importance as an alternative for businesses seeking to consolidate and restructure their debt. *Venture capital funds*, with a score of 0.517, provides capital for distressed businesses, which can be used to restructure their existing debt. However, the higher risks and the loss of equity control can be potential downsides factors.

## 5. Discussion

*Traditional loans* are confirmed as the top-ranked source of financing, according to both the stand-alone model and the comparison analysis for each SMEs funding requirement. SMEs may find these loans accessible and characterized by predictable terms, making them an attractive option for financial planning and budgeting purposes. Nevertheless, SMEs should consider the strict eligibility criteria and collateral requirements, which can be challenging for some businesses, particularly start-ups and those with less stable financial histories (Riding *et al.*, 2007).

In the last decade, the development of digital technology in the financial sector has led to the emergence of new channels of financing, including *P2P lending*. These funding platforms are able to connect SMEs directly with crowd-lenders, potentially offering a more efficient and streamlined lending process. These features could ensure faster capital access with fewer bureaucratic hurdles, making this instrument a good option for SMEs needing quick access to finance. However, the P2P lending platforms' fix interest rates may be higher than traditional loans, reflecting the higher risk perceived by individual lenders and the absence of guarantees for the applicant firms (Chen *et al.*, 2020; Stefanelli *et al.*, 2022).

Concerning the *Venture Capital Funds*, our analysis confirms how this alternative represents a relevant source of funding, particularly useful for SMEs with high growth potential. In exchange for capital, they are required to relinquish a share of ownership. These mechanisms could potentially impact the small and medium-sized enterprise's future direction and strategic decision-making.

Beside these funding options, issuing *Bonds* can be a viable method to raise substantial funding without diluting ownership. However, SMEs must recognise that issuing bonds means committing to regular interest payments and the return of principal at maturity, which requires careful financial planning and management (Mietzner *et al.*, 2018). Differently, *Factoring* enables immediate cash flows by selling invoices to a third party at a discount. This solution can aid with short-term liquidity requirements but frequently carries higher costs than conventional banking loans.

Additionally, *Factoring* may potentially affect customer relationships as debt collection is taken over by the factoring company. In the face of new investments, *Leasing* is an efficient solution for SMEs to gain access to the equipment or property they need without incurring significant up-front costs. The cost is distributed over time, which aids SMEs in better managing their cash flow. Nevertheless, the total expense over the lease period may exceed the expenditure incurred in buying the assets outright (Cosci *et al.*, 2015).

*Equity Crowdfunding* is a valuable source of funding for SMEs, particularly for those with a substantial customer base open to investment. A well-articulated business plan and a strong marketing strategy are necessary to attract sufficient investors (Hornuf and Schwienbacher, 2017). Among other sources examined, *Private Equity* can provide significant capital injection for SMEs seeking growth, similar to venture capital. Furthermore, *Sovereign Funds* and *Business Angels* can provide substantial funding, but they often have specific expectations or stipulations. Thus, SMEs need to be prepared for the high level of scrutiny, long approval times, and the possibility of losing autonomy over business decisions (Ferreira and Saridakis, 2017).

More in detail, when analysing SMEs' funding needs, the spherical ARAS fuzzy results provide understandings into how the ranking of funding sources varies according to a defined subset of criteria. When SMEs consider new investments, they commonly prefer traditional loans. This preference is rooted in the reliability and familiarity associated with traditional loans. Firms consider banking loans reliable and familiar, and this preference is rooted in that perception. *Traditional loans* have well-defined repayment terms and interest rates, allowing for predictability in financial planning. This characteristic helps SMEs estimate future cash outflows accurately, leading to the development of an effective growth strategy. Moreover, banks and other financial institutions that provide these loans usually offer financial advice and support that could benefit SMEs.

Nevertheless, strict eligibility criteria, such as credit checks and collateral requirements, might cause obstacles for some SMEs (Bertoni *et al.*, 2023). These might encounter difficulties in obtaining conventional loans, especially if they are start-ups, have a limited credit history, or do not have assets to offer as collateral. Under such circumstances, leasing can be a favourable option. SMEs can use essential assets like machinery, vehicles, or premises for a specified period without purchasing them outright through leasing. As a result, the need for significant upfront capital investment, which can frequently serve as a limitation for SMEs, is eliminated. Instead, they can spread the cost over time through regular lease payments, helping them to maintain liquidity and better manage their cashflows. *Leasing* transfers the risk of asset depreciation to the lessor and may include maintenance, thereby diminishing the financial burden and risk for SMEs. The literature suggests *Leasing* is an attractive option for businesses looking to expand their operations without incurring significant initial costs (Lasfer and Levis, 1998).

Regarding the liquidity needs of SMEs, traditional loans are often preferred. Banks and other established financial institutions usually provide these loans and have an easily accessible application process. This allows SMEs to obtain funds within a relatively short time frame. The flexibility of various repayment schedules and interest rate options accompanies these loans, allowing SMEs to choose the option that suits their cashflows requirements. In addition to the strengths of traditional loans, emerging financial mechanisms, like *P2P lending*, also offer significant benefits. Stefanelli *et al.* (2022) defined P2P lending as an online platform-based service that matches borrowers directly with lenders. This platform circumvents traditional banking systems, resulting in a simplified, quicker, and more effective loan approval process. Therefore, SMEs can efficiently obtain the necessary funds to sustain their business operations. This lending process can prove especially advantageous to newly established SMEs or those with non-conventional financial profiles who may find it challenging to fulfil the strict requirements imposed by traditional banks (Gao *et al.*, 2018). *Equity crowdfunding*, although not the most effective funding method for meeting liquidity requirements, has unique advantages. Equity crowdfunding enables small and medium-sized enterprises (SMEs) to raise the necessary funds by inviting several investors, each of whom can contribute a small amount of capital. This approach can help SMEs gain validation for their business ideas and models from a broad range of potential stakeholders (Eldridge *et al.*, 2021).

Finally, *Sovereign Funds* or Development Funding offer an additional option to provide liquidity support. The government usually supports these funds and aims to promote economic development and growth in specific sectors. Despite the possible specific requirements and lower availability than other options, these funds can offer significant support for eligible SMEs. They can provide low-interest rates, longer repayment periods, or funding for projects that align with the government's strategic initiatives (Ferreira and Saridakis, 2017).

*Traditional loans* usually emerge as the most favoured option for SMEs when prioritising debt restructuring. Debt restructuring modifies the terms of existing debt agreements to improve a firm's financial sustainability. During this process, traditional loans, with their well-defined repayment schedules and interest rates, can provide the necessary stability and predictability that SMEs require (Grunert and Norden, 2012). Loans providers, including banks, may offer restructuring options, such as extending loan terms or reducing interest rates, to alleviate financial stress and help SMEs in regaining financial stability. Nonetheless, the approval process for traditional loans could be challenging for SMEs who are already experiencing financial difficulties since banks may perceive them as high-risk borrowers. Furthermore, if the debt load is significant, traditional loan restructuring may not be sufficient.

In these circumstances, financing methods such as *Peer-to-peer (P2P) Lending* and *Venture Capital* funds can instead provide an accessible source of finance. P2P loans typically

offer more flexible terms and quicker access to capital, making them an attractive option for small and medium-sized enterprises (SMEs) requiring immediate cash flow to fulfil their outstanding debts. Nevertheless, interest rates may be comparatively higher due to the perceived risk of lending to financially troubled businesses and such risks need to be evaluated carefully (Chen *et al.*, 2020).

The study has different practical contributions. Firstly, recognizing the importance of different financial products for different circumstances can help banks tailor their offerings and strengthen their relationships with SME customers. Regarding *new investments*, SMEs have preferred traditional loans, reflecting their preference for the features that characterise this instrument, such as reliability and predictability. From a banking perspective, this emphasises the continued significance of conventional products and services, despite a rapidly developing financial industry. Small and medium-sized enterprises' preference for traditional loans highlights banks' need to provide such products with explicit conditions, approachable assistance, and trustworthy guidance (Nakku *et al.*, 2020). The interest in leasing as an alternative implies a growth area for banks, offering more versatile and reasonable solutions for asset procurement.

Concerning liquidity requirements, SMEs' preference for traditional loans demonstrates their appreciation for flexible and easy sources. From the banking perspective, this highlights the significance of providing loans with flexible repayment schedules and different interest rate options (Cressy and Olofsson, 1997; De Blasio *et al.*, 2018). Banks need to ensure that they are able to offer loans that are easy to repay. Nevertheless, the increasing preference for P2P lending implies that banks may face more competition from creative, efficient, and comprehensive lending platforms. This points to banks' need to modernize their lending practices, potentially through digital transformations, to improve efficiency and customer satisfaction (Mustafa and Yaakub, 2018).

Regarding the *Debt restructuring*, the preference for traditional loans emphasises the significance of predictability and stability. Banks can assist SMEs in navigating financial difficulties by offering restructuring options and expert advice, playing a significant role in this process. However, the significance of P2P lending and venture capital in these scenarios emphasises banks' need to provide high-risk SMEs with more responsive and flexible solutions. Banks may need to collaborate with alternative financing platforms to meet these demands or design innovative products themselves (Levy and Powell, 1998; Whyman and Petrescu, 2015).

## 6. Conclusion

While existing research confirms that traditional bank lending remains the most effective funding channel for SMEs, our study proposes a more refined approach. We utilize a multi-criteria decision-making framework to evaluate alternative finance tools, assessing these options across six critical metrics: *Interest Rate, Flexibility, Accessibility, Advisory Support, Riskiness,* and *Approval Time*. Additionally, our analysis considers the specific financial needs of SMEs, such as *New Investments, Liquidity Requirements, and Debt Restructuring*. This method provides a comprehensive evaluation that is directly applicable to the diverse financial challenges faced by SMEs. By integrating the characteristics of financial instruments with the specific financial contexts of SMEs, our findings present valuable understandings into strategic financing decisions. Our findings not only confirm the importance of traditional banking but also illustrate how alternative financing can be strategically utilized to support SMEs at various stages of their business operations. This provides a practical guide for financial institutions and SMEs to enhance their financial planning and management strategies.

At the same time, the study emphasizes the growing importance of alternative sources of finance, such as P2P lending and leasing. P2P lending offers an opportunity for a more efficient and streamlined lending process that can provide faster access to capital. This trend suggests that banks may need to adapt and innovate to compete effectively in the financial industry, including digital transformation initiatives to improve lending efficiency and customer satisfaction.

When the business financial goal is debt restructuring, predictability and stability are critical, and thus traditional loans again emerge as the most favoured option. Banks can play a significant role in this process by offering restructuring options and expert advice. However, the importance of P2P lending and venture capital in these scenarios underscores the need for banks to provide more flexible, responsive solutions for high-risk SMEs.

The implications of this study, interpreted through the Transaction Cost Economics (TCE) theory, suggest reducing transaction costs, which supports the growing use of alternative financing sources such as P2P lending and crowdfunding. These methods often exploit digital platforms to lower transaction costs associated with traditional financing, simplifying capital access, and decreasing information asymmetry. Banks are encouraged to innovate their lending practices to stay competitive. Such innovation could involve digital transformations that streamline processes and improve customer satisfaction, as well as forming partnerships with alternative financing platforms to expand their offerings. Policymakers, should regulate and monitor these emerging financial platforms to ensure fairness and protect stakeholder interests. Regulation should support innovation in SMEs financing while guarding against potential risks. Encouraging banks to incorporate digital solutions into their funding services could enhance their competitiveness.

SMEs should actively explore and evaluate the various financing options available, considering both short-term benefits and long-term impacts. Aligning financing strategies with business needs and potential impacts on equity and debt is crucial. This approach, suggested by TCE theory, will help SMEs optimize their financial management for sustainable growth and operational stability.

This study relies significantly on financial experts' subjective expertise and judgement to rank and evaluate the various methods of financing SMEs. As a result, the study has certain limitations. One of the limitations of the suggested methodology is that it may be subject to expert bias. Building consensus is difficult in group decision-making activities, as in any MCDA approach. Thus, however every effort was made to ensure a comprehensive and unbiased representation; individual bias or varied expertise levels could potentially affect the conclusions drawn. Future research could improve this by using a more quantifiable, data-driven approach to analyse and compare financing options. This could include the development of more sophisticated ranking algorithms or the careful use of artificial intelligence and machine learning technologies. We suggest academics to classify SMEs into categories such as established, emerging, startups, and high-growth companies in their future studies in order to assess whether different types of SMEs have distinct preferences for accessing alternative finance tools.

## References

Agostino, M., Gagliardi, F. and Trivieri, F. (2012), "Bank competition, lending relationships and firm default risk: an investigation of Italian SMEs", *International Small Business Journal*, Vol. 30 No. 8, pp. 907-943, doi: 10.1177/0266242611416681.

Aydoğdu, A. and Gül, S. (2022), "New entropy propositions for interval-valued spherical fuzzy sets and their usage in an extension of ARAS (ARAS-IVSFS)", *Expert Systems*, Vol. 39 No. 4, e12898.

Baas, T. and Schrooten, M. (2006), "Relationship banking and SMEs: a theoretical analysis", *Small Business Economics*, Vol. 27 Nos 2-3, pp. 127-137, doi: 10.1007/s11187-006-0018-7.
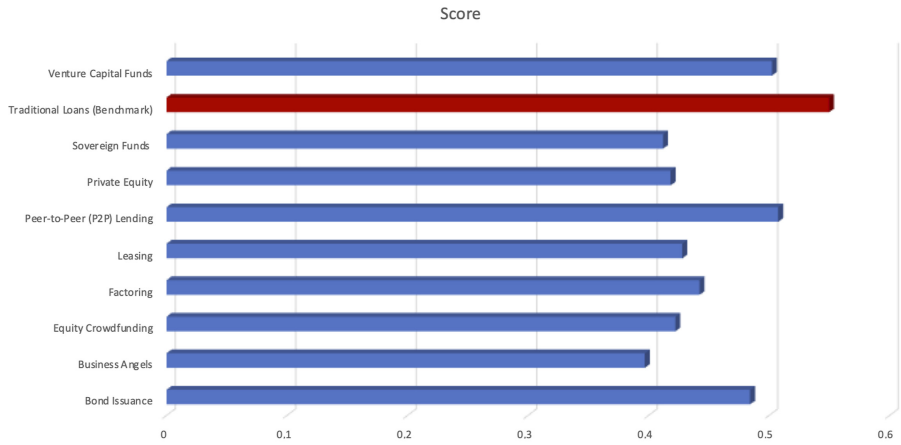
Bartoli, F., Ferri, G., Murro, P. and Rotondi, Z. (2013), "Bank–firm relations and the role of Mutual Guarantee Institutions at the peak of the crisis", *Journal of Financial Stability*, Vol. 9 No. 1, pp. 90-104, doi: 10.1016/j.jfs.2012.03.003.

Beck, T. and Demirguc-Kunt, A. (2006), "Small-medium enterprise sector: access to finance as a growth constraint", *Journal of Banking and Finance*, Vol. 30 No. 11, pp. 2931-2943, doi: 10.1016/j.jbankfin.2006.05.009.

Bellucci, A., Borisov, A. and Zazzaro, A. (2010), "Does gender matter in bank–firm relationships? Evidence from small business lending", *Journal of Banking and Finance*, Vol. 34 No. 12, pp. 2968-2984, doi: 10.1016/j.jbankfin.2010.07.008.

Berger, A.N. and Schaeck, K. (2011), "Small and medium-sized enterprises, bank relationship strength, and the use of venture capital", *Journal of Money, Credit and Banking*, Vol. 43 Nos 2-3, pp. 461-490, doi: 10.1111/j.1538-4616.2010.00381.x.

Berger, A.N. and Udell, G.F. (1995), "Relationship lending and lines of credit in small firm finance", *Journal of Business*, Vol. 68 No. 3, pp. 351-382, doi: 10.1086/296668.

Bertoni, F., Ferrer, M.A. and Martí, J. (2013), "The different roles played by venture capital and private equity investors on the investment activity of their portfolio firms", *Small Business Economics*, Vol. 40 No. 3, pp. 607-633, doi: 10.1007/s11187-011-9384-x.

Bertoni, F., Colombo, M.G. and Quas, A. (2023), "The long-term effects of loan guarantees on SME performance", *Journal of Corporate Finance*, Vol. 80, 102408, doi: 10.1016/j.jcorpfin.2023.102408.

Bu, Y., Du, X., Wang, Y., Liu, S., Tang, M. and Li, H. (2024), "Digital inclusive finance: a lever for SME financing?", *International Review of Financial Analysis*, Vol. 93, 103115, doi: 10.1016/j.irfa.2024.103115.

Casey, E. and O'Toole, C.M. (2014), "Bank lending constraints, trade credit and alternative financing during the financial crisis: evidence from European SMEs", *Journal of Corporate Finance*, Vol. 27, pp. 173-193, doi: 10.1016/j.jcorpfin.2014.05.001.

Chen, Y., Xu, L. and Wang, W. (2009), "Innovation fund: a booster of science and technology SME development", *International Journal of Business and Management*, Vol. 4 No. 4, pp. 106-109, April, doi: 10.5539/ijbm.v4n4p106.

Chen, S., Gu, Y., Liu, Q. and Tse, Y. (2020), "How do lenders evaluate borrowers in peer-to-peer lending in China?", *International Review of Economics and Finance*, Vol. 69, pp. 651-662, doi: 10.1016/j.iref.2020.06.038.

Coakley, J. and Lazos, A. (2021), "New developments in equity crowdfunding: a review", *Review of Corporate Finance*, Vol. 1 Nos 3-4, pp. 341-405, doi: 10.1561/114.00000008.

Cook, P. and Nixson, F. (2000), *Finance and Small and Medium-Sized Enterprise Development*, Institute for Development Policy and Management, University of Manchester, Manchester.

Cosci, S., Guida, R. and Meliciani, V. (2015), "Leasing decisions and credit constraints: empirical analysis on a sample of Italian firms", *European Financial Management*, Vol. 21 No. 2, pp. 377-398, doi: 10.1111/eufm.12019.

Cotugno, M., Monferrà, S. and Sampagnaro, G. (2013a), "Relationship lending, hierarchical distance and credit tightening: evidence from the financial crisis", *Journal of Banking and Finance*, Vol. 37 No. 5, pp. 1372-1385, doi: 10.1016/j.jbankfin.2012.07.026.

Cotugno, M. and Stefanelli, V. (2012), "Geographical and product diversification during instability financial period: Good or bad for banks?", available at: https://ssrn.com/abstract=1989919

Cotugno, M., Stefanelli, V. and Torluccio, G. (2013b), "Relationship lending, default rate and loan portfolio quality", *Applied Financial Economics*, Vol. 23 No. 7, pp. 573-587, doi: 10.1080/09603107.2012.744133.

Cressy, R. and Olofsson, C. (1997), "European SME financing: an overview", *Small Business Economics*, Vol. 9 No. 2, pp. 87-96, doi: 10.1023/a:1007921004599.

Croce, A., Ughetto, E., Bonini, S. and Capizzi, V. (2021), "Gazelles, ponies, and the impact of business angels' characteristics on firm growth", *Journal of Small Business Management*, Vol. 59 No. 2, pp. 223-248, doi: 10.1080/00472778.2020.1844489.

De Blasio, G., De Mitri, S., D'Ignazio, A., Russo, P.F. and Stoppani, L. (2018), "Public guarantees to SME borrowing. A RDD evaluation", *Journal of Banking and Finance*, Vol. 96, pp. 73-86, doi: 10. 1016/j.jbankfin.2018.08.003.

De la Torre, A., Pería, M.S.M. and Schmukler, S.L. (2010), "Bank involvement with SMEs: beyond relationship lending", *Journal of Banking and Finance*, Vol. 34 No. 9, pp. 2280-2293, doi: 10.1016/ j.jbankfin.2010.02.014.

Degryse, H. and Ongena, S. (2001), "Bank relationships and firm profitability", *Financial Management*, Vol. 30 No. 1, pp. 9-34, doi: 10.2307/3666389.

Doumpos, M. and Figueira, J.R. (2019), "A multicriteria outranking approach for modeling corporate credit ratings: an application of the Electre TrinC method", *Omega*, Vol. 82, pp. 166-180, doi: 10. 1016/j.omega.2018.01.003.

Eldridge, D., Nisar, T.M. and Torchia, M. (2021), "What impact does equity crowdfunding have on SME innovation and growth? An empirical study", *Small Business Economics*, Vol. 56 No. 1, pp. 105-120, doi: 10.1007/s11187-019-00210-4.

Farag, H. and Johan, S. (2021), "How alternative finance informs central themes in corporate finance", *Journal of Corporate Finance*, Vol. 67, 101879, doi: 10.1016/j.jcorpfin.2020.101879.

Fasano, F. and La Rocca, T. (2023), "Does the bank-firm human relationship still matter for SMEs? The game-changing role of digitalization", *Small Business Economics*, Vol. 62, pp. 1-20, doi: 10. 1007/s11187-023-00758-2.

Fasano, F. and La Rocca, T. (2024), "Does the bank-firm human relationship still matter for SMEs? The game-changing role of digitalization", *Small Business Economics*, Vol. 62 No. 1, pp. 159-178, doi: 10.1007/s11187-023-00758-2.

Ferreira, P. and Saridakis, G. (2017), "Firm shutdown during the financial and the sovereign debt crises: empirical evidence from Portugal", *International Journal of the Economics of Business*, Vol. 24 No. 2, pp. 153-179, doi: 10.1080/13571516.2017.1309105.

Ferri, G. and Messori, M. (2000), "Bank–firm relationships and allocative efficiency in Northeastern and Central Italy and in the South", *Journal of Banking and Finance*, Vol. 24 No. 6, pp. 1067-1095, doi: 10.1016/s0378-4266(99)00118-1.

Foltz, J.D. (2004), "Credit market access and profitability in Tunisian agriculture", *Journal of Agricultural Economics*, Vol. 30 No. 3, pp. 229-240, doi: 10.1111/j.1574-0862.2004.tb00191.x.

Gadekar, R., Sarkar, B. and Gadekar, A. (2022), "Key performance indicator based dynamic decision-making framework for sustainable Industry 4.0 implementation risks evaluation: reference to the Indian manufacturing industries", *Annals of Operations Research*, Vol. 318 No. 1, pp. 189-249, doi: 10.1007/s10479-022-04828-8.

Gao, G.X., Fan, Z.P., Fang, X. and Lim, Y.F. (2018), "Optimal Stackelberg strategies for financing a supply chain through online peer-to-peer lending", *European Journal of Operational Research*, Vol. 267 No. 2, pp. 585-597, doi: 10.1016/j.ejor.2017.12.006.

Garcia-Tabuenca, A. and Crespo-Espert, J.L. (2010), "Credit guarantees and SME efficiency", *Small Business Economics*, Vol. 35 No. 1, pp. 113-128, doi: 10.1007/s11187-008-9148-4.

García-Teruel, P.J. and Martínez-Solano, P. (2008), "On the determinants of SME cash holdings: evidence from Spain", *Journal of Business Finance and Accounting*, Vol. 35 Nos 1-2, pp. 127-149, doi: 10.1111/j.1468-5957.2007.02022.x.

Gocer, F. and Sener, N. (2022), "Spherical fuzzy extension of AHP-ARAS methods integrated with modified k-means clustering for logistics hub location problem", *Expert Systems*, Vol. 39 No. 2, e12886.

Grunert, J. and Norden, L. (2012), "Bargaining power and information in SME lending", *Small Business Economics*, Vol. 39 No. 2, pp. 401-417, doi: 10.1007/s11187-010-9311-6.

Hornuf, L. and Schwienbacher, A. (2017), "Should securities regulation promote equity crowdfunding?", *Small Business Economics*, Vol. 49 No. 3, pp. 579-593, doi: 10.1007/s11187-017-9839-9.
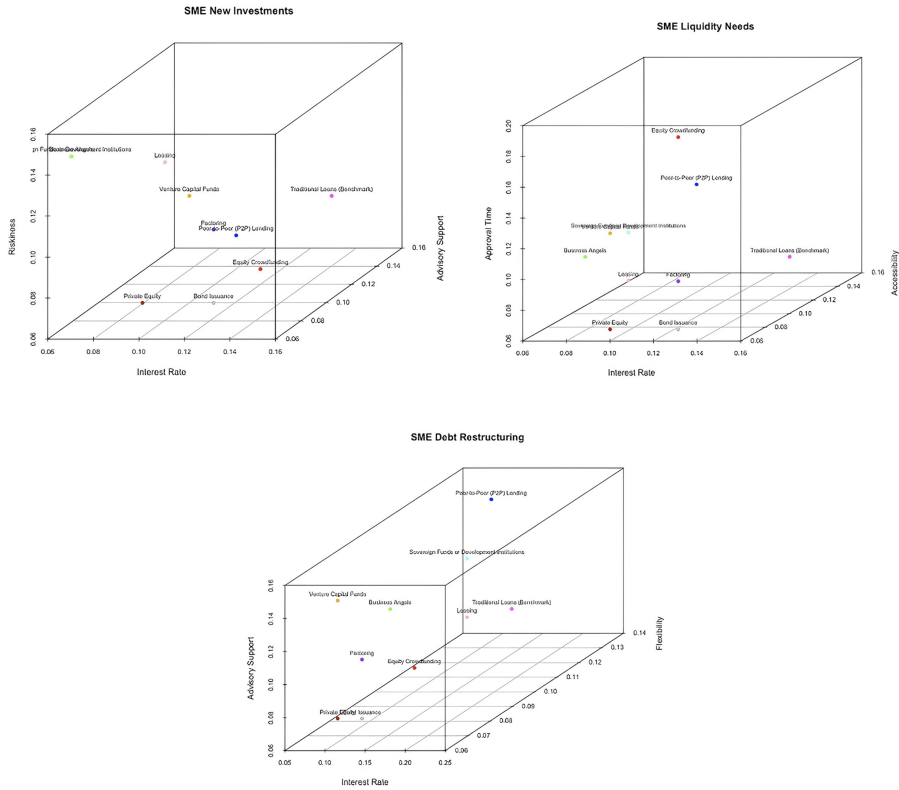
Jakšič, M. and Marinč, M. (2019), "Relationship banking and information technology: the role of artifcial intelligence and Fintech", *Risk Management*, Vol. 21 No. 1, pp. 1-18, doi: 10.1057/s41283-018-0039-y.

Klapper, L. (2006), "The role of factoring for financing small and medium enterprises", *Journal of Banking and Finance*, Vol. 30 No. 11, pp. 3111-3130, doi: 10.1016/j.jbankfin.2006.05.001.

Lasfer, M.A. and Levis, M. (1998), "The determinants of the leasing decision of small and large companies", *European Financial Management*, Vol. 4 No. 2, pp. 159-184, doi: 10.1111/1468-036x.00062.

Lerner, J. and Nanda, R. (2020), "Venture capital's role in financing innovation: what we know and how much we still need to learn", *Journal of Economic Perspectives*, Vol. 34 No. 3, pp. 237-261, doi: 10.1257/jep.34.3.237.

Levy, M. and Powell, P. (1998), "SME flexibility and the role of information systems", *Small Business Economics*, Vol. 11 No. 2, pp. 183-196, doi: 10.1023/a:1007912714741.

Li, X., Ye, Y., Liu, Z., Tao, Y. and Jiang, J. (2024), "FinTech and SME'performance: evidence from China", *Economic Analysis and Policy*, Vol. 81, pp. 670-682.

Lou, Z., Xie, Q., Shen, J.H. and Lee, C.C. (2024), "Does supply chain finance (SCF) alleviate funding constraints of SMEs? Evidence from China", *Research in International Business and Finance*, Vol. 67, 102157, doi: 10.1016/j.ribaf.2023.102157.

Luo, P., Wang, H. and Yang, Z. (2016), "Investment and financing for SMEs with a partial guarantee and jump risk", *European Journal of Operational Research*, Vol. 249 No. 3, pp. 1161-1168, doi: 10.1016/j.ejor.2015.09.032.

Ma, Z.M., Yang, W., Li, L. and Xu, Z. (2023), "Ranking fuzzy numbers using additive priority degrees", *Expert Systems with Applications*, Vol. 234, 121019.

Mamatzakis, E.C., Ongena, S. and Tsionas, M.G. (2021), "Does alternative finance moderate bank fragility? Evidence from the euro area", *Journal of International Financial Markets, Institutions and Money*, Vol. 72, 101340, doi: 10.1016/j.intfin.2021.101340.

Mason, C., Botelho, T. and Zygmunt, J. (2017), "Why business angels reject investment opportunities: is it personal?", *International Small Business Journal*, Vol. 35 No. 5, pp. 519-534, doi: 10.1177/0266242616646622.

Menekşe, A. and Camgöz Akdağ, H. (2022), "Distance education tool selection using novel spherical fuzzy AHP EDAS", *Soft Computing*, Vol. 26 No. 4, pp. 1617-1635.

Mietzner, M., Proelss, J. and Schweizer, D. (2018), "Hidden champions or black sheep? The role of underpricing in the German mini-bond market", *Small Business Economics*, Vol. 50 No. 2, pp. 375-395, doi: 10.1007/s11187-016-9833-7.

Mol-Gómez-Vázquez, A., Hernández-Cánovas, G. and Koëter-Kant, J. (2018), "Legal and institutional determinants of factoring in SMEs: empirical analysis across 25 European countries", *Journal of Small Business Management*, Vol. 56 No. 2, pp. 312-329, doi: 10.1111/jsbm.12260.

Mustafa, H.K. and Yaakub, S. (2018), "Innovation and technology adoption challenges: impact on SMEs' company performance", *International Journal of Accounting*, Vol. 3 No. 15, pp. 57-65.

Nakku, V.B., Agbola, F.W., Miles, M.P. and Mahmood, A. (2020), "The interrelationship between SME government support programs, entrepreneurial orientation, and performance: a developing economy perspective", *Journal of Small Business Management*, Vol. 58 No. 1, pp. 2-31, doi: 10.1080/00472778.2019.1659671.

OECD (1997), *Small Businesses, Job Creation and Growth: Facts, Obstacles and Best Practices*, OECD, Paris.

OECD (2018), "Alternative financing instruments for SMEs and entrepreneurs: the case of capital market finance", (By Thompson, J., Boschmans, K., and Pissareva, L.), OECD Papers on SMEs and Entrepreneurship.

Ono, A. and Uesugi, I. (2009), "Role of collateral and personal guarantees in relationship lending: evidence from Japan's SME loan market", *Journal of Money, Credit and Banking*, Vol. 41 No. 5, pp. 935-960, doi: 10.1111/j.1538-4616.2009.00239.x.

Paglia, J.K. and Harjoto, M.A. (2014), "The effects of private equity and venture capital on sales and employment growth in small and medium-sized businesses", *Journal of Banking and Finance*, Vol. 47, pp. 177-197, doi: 10.1016/j.jbankfin.2014.06.023.

Pierrakis, Y. (2019), "Peer-to-peer lending to businesses: investors' characteristics, investment criteria and motivation", *The International Journal of Entrepreneurship and Innovation*, Vol. 20 No. 4, pp. 239-251, doi: 10.1177/1465750319842528.

Riding, A., Madill, J. and Haines, G. (2007), "Incrementality of SME loan guarantees", *Small Business Economics*, Vol. 29, pp. 47-61.

Roux, S. and Savignac, F. (2024), "SMEs' financing in the aftermath of the financial and sovereign debt crises: a comparison across euro area countries", *Journal of International Money and Finance*, Vol. 142, 103020, doi: 10.1016/j.jimonfin.2024.103020.

Seyfi-Shishavan, S.A., Donyatalab, Y., Farrokhizadeh, E. and Satoglu, S.I. (2021), "A fuzzy optimization model for designing an efficient blood supply chain network under uncertainty and disruption", *Annals of Operations Research*, Vol. 331, pp. 1-55, doi: 10.1007/s10479-021-04123-y.

Sheng, T. (2021), "The effect of fintech on banks' credit provision to SMEs: evidence from China", *Finance Research Letters*, Vol. 39, 101558, doi: 10.1016/j.frl.2020.101558.

Singh, R.K., Gunasekaran, A. and Kumar, P. (2018), "Third party logistics (3PL) selection for cold chain management: a fuzzy AHP and fuzzy TOPSIS approach", *Annals of Operations Research*, Vol. 267 Nos 1-2, pp. 531-553, doi: 10.1007/s10479-017-2591-3.

Sinyard, D.B., Dionne, S.S. and Loch, K.D. (2020), "Fast thinking in private equity: the role of heuristics in screening buyout opportunities", *Journal of Small Business Management*, Vol. 58 No. 6, pp. 1221-1255, doi: 10.1111/jsbm.12451.

Sohn, S.Y. and Jeon, H. (2010), "Competing risk model for technology credit fund for small and medium-sized enterprises", *Journal of Small Business Management*, Vol. 48 No. 3, pp. 378-394, doi: 10.1111/j.1540-627x.2010.00299.x.

Stefanelli, V., Ferilli, G.B. and Boscia, V. (2022), "Exploring the lending business crowdfunding to support SMEs' financing decisions", *Journal of Innovation and Knowledge*, Vol. 7 No. 4, 100278, doi: 10.1016/j.jik.2022.100278.

Stefani, U., Schiavone, F., Laperche, B. and Burger-Helmchen, T. (2020), "New tools and practices for financing novelty: a research agenda", *European Journal of Innovation Management*, Vol. 23 No. 2, pp. 314-328, doi: 10.1108/ejim-08-2019-0228.

Thakor, A. (2020), "Fintech and banking: what do we know?", *Journal of Financial Intermediation*, Vol. 41, 100833, doi: 10.1016/j.jfi.2019.100833.

Tiberius, V. and Hauptmeijer, R. (2021), "Equity crowdfunding: forecasting market development, platform evolution, and regulation", *Journal of Small Business Management*, Vol. 59 No. 2, pp. 337-369, doi: 10.1080/00472778.2020.1849714.

Venkatesh, V.G., Zhang, A., Deakins, E., Luthra, S. and Mangla, S. (2019), "A fuzzy AHP-TOPSIS approach to supply partner selection in continuous aid humanitarian supply chains", *Annals of Operations Research*, Vol. 283 Nos 1-2, pp. 1517-1550, doi: 10.1007/s10479-018-2981-1.

Whyman, P.B. and Petrescu, A.I. (2015), "Workplace flexibility practices in SMEs: relationship with performance via redundancies, absenteeism, and financial turnover", *Journal of Small Business Management*, Vol. 53 No. 4, pp. 1097-1126, doi: 10.1111/jsbm.12092.

Williamson, O.E. (1989), "Transaction cost economics", in *Handbook of Industrial Organization*, Vol. 1, pp. 135-182.

Yin, M. and Li, J. (2023), "How market orientation affects open innovation? Exploring the role of information and communication technology capability", *European Journal of Innovation Management*, Vol. 27 No. 6, pp. 1885-1911, doi: 10.1108/ejim-08-2022-0401.

Zhou, N. and Sun, R. (2024), "Coping with the storm: the role of fintech in SME survival", *International Review of Financial Analysis*, Vol. 93, 103157, doi: 10.1016/j.irfa.2024.103157.

**Appendix 1**

Score



**Figure A1.**
SME financing
alternatives ordered
by Ki

**Source(s):** Authors' own creation

**Appendix 2**



**SME New Investments**

**SME Liquidity Needs**

**SME Debt Restructuring**

**Source(s):** Authors' own creation

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