Evaluating Student Entrepreneurship Determinants using Hybrid Fuzzy Decision Models

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ABSTRACT

Student entrepreneurship allows university students to acquire entrepreneurial skills, expand practical business knowledge and generate income while studying. However, various determinants or factors influence its success and require systematic evaluation to understand their relationship. This study aims to identify, evaluate, and analyse the determinants influencing student entrepreneurship using an integrated Fuzzy Analytic Hierarchy Process (AHP) and Fuzzy Decision-Making Trial and Evaluation Laboratory (Fuzzy DEMATEL) approach. Based on the literature review and expert validation, six determinants were identified: Time Management, Financial Resources, Competition, Customer Behaviour, Operational Challenges, and Entrepreneurial Skills. Via structured questionnaires and guided interview sessions, data collection involved six experts, including three entrepreneurship lecturers and three student entrepreneur. Fuzzy AHP was used to examine the importance and priority of the determinants, while Fuzzy DEMATEL was used to provide their causal relationships, thus and categorize them into cause and effect groups. The Fuzzy AHP results revealed that Financial Resources was the highest-priority determinant, with a weight of 0.30576, followed by Entrepreneurial Skills (0.26020) and Operational Challenges (0.18779). In contrast, the Fuzzy DEMATEL results indicated that Operational Challenges and Entrepreneurial Skills were cause factors, while Time Management, Financial Resources, Competition, and Customer Behaviour were effect factors. Entrepreneurial Skills had the highest positive relation value, making it the strongest driving factor. These findings show that the highest-priority determinant is not always the strongest driving factor, highlighting the significance of integrating Fuzzy AHP and Fuzzy DEMATEL. The hybrid model identifies priority determinants and their causal relationships, offering a basis for developing targeted strategies to support student entrepreneurship.

Keywords: Student entrepreneurship; Fuzzy AHP; Fuzzy DEMATEL; Determinants; Multi-Criteria Decision Making

INTRODUCTION

Student entrepreneurship has become increasingly common, as many university students are involved in small business activities to earn additional income, gain experience, and develop entrepreneurial skills while pursuing their academic studies [1]. Universities have responded by launching entrepreneurship programmes and initiatives to support this trend [2]. Student entrepreneurship helps students apply academic knowledge in real business situations while developing skills such as problem-solving, decision-making, and financial management. It also builds entrepreneurial mind-sets and prepares students for future employment. Therefore,

understanding the factors influencing student entrepreneurship is important for strengthening university entrepreneurship education and support. However, managing entrepreneurial activities alongside academic responsibilities remains a challenge, and student entrepreneurs often face difficulties that affect their entrepreneurial performance [3].

Previous studies have identified various determinants that influence student entrepreneurship, including time management, financial resources, competition, customer behaviour, operational challenges, and entrepreneurial skills [4, 5, 6]. However, findings across these studies remain inconsistent, as different studies focus on different contexts, populations, and research variables [7]. In addition, most of these studies examine the factors separately, without determining which factor is more important or how the factors interact with one another. Furthermore, previous studies have used conventional statistical methods such as regression analysis and Structural Equation Modelling (SEM) [8] to examine relationships between variables. While effective for hypothesis testing, these methods face difficulty managing multiple factors simultaneously and analysing the causal relationships among them.

To address this gap, a more systematic decision-making approach is needed that can evaluate the relative importance of determinants while also examining the relationships among them. The Fuzzy Analytic Hierarchy Process (Fuzzy AHP) is an extension of the conventional AHP that incorporates fuzzy set theory to handle uncertainty in expert judgments, allowing preferences to be expressed through linguistic terms converted into triangular fuzzy numbers [9, 10]. Complementing this, the Fuzzy Decision-Making Trial and Evaluation Laboratory (Fuzzy DEMATEL) method analyses cause-and-effect relationships among factors, distinguishing determinants that drive others (cause factors) from those that are largely influenced (effect factors) [11, 12]. The integration of Fuzzy AHP and Fuzzy DEMATEL has been applied effectively in other decision-making domains, for instance in analysing sustainable supply chain factors in the mining industry, where the integrated approach was used to both prioritise sustainability factors and map their interdependencies [13]. However, this integration remains largely unexplored in the context of student entrepreneurship.

This study aims to identify, evaluate and rank the relative importance of student entrepreneurship factors using Fuzzy AHP, and to analyse the causal relationships among the factors using Fuzzy DEMATEL. The research focuses on student entrepreneurs and entrepreneurship lecturers at Universiti Teknologi MARA Cawangan Terengganu Kampus Kuala Terengganu (UiTMCTKKT), considering six key determinants of student entrepreneurship. Because this decision involves specialized details, a small team of domain experts is consulted rather than running a broad public survey. A standard survey falls short here because evaluating how these factors interact requires hands-on experience. The factors are directly compared by the chosen experts, and fuzzy concept is used to capture any grey areas or hesitation in their assessments. Trustworthy, realistic answers are produced by this approach without the need to chase down a massive sample size. The findings are expected to provide useful insights for students, educators, and university management in prioritising the determinants most critical to strengthening student entrepreneurship.

METHODOLOGY

The determinants used to evaluate student entrepreneurship were carefully selected based on an extensive literature review, initial observations, and expert interviews. Six determinants were identified: time management (F1), financial resources (F2), competition (F3), customer behaviour (F4), operational challenges (F5), and entrepreneurial skills (F6). Details of the determinant descriptions are presented in Table 1.

Table 1. Determinants/factors of Student Entrepreneurship

Code	Determinant	Description
F1	Time Management	The ability to balance business activities with academic responsibilities and other commitments.
F2	Financial Resources	Access to capital, savings, or funding needed to start and sustain business operations.
F3	Competition	The presence of rival businesses offering similar products or services,

		particularly around campus.
F4	Customer Behaviour	Customer preferences, purchasing patterns, and expectations that affect business performance.
F5	Operational Challenges	Day-to-day business constraints such as inventory, transportation, and supplier reliability.
F6	Entrepreneurial Skills	Competencies such as marketing, communication, financial management, and problem-solving.

Six experts were selected to provide judgments which are three student entrepreneurs who had operated a business for at least three semesters (approximately twelve months), and three entrepreneurship lecturers with at least ten years of teaching and professional experience. Because the problem involves complex links between practical and technical areas, feedback is collected from a small group of experts using fuzzy decision-making methods. Unlike common survey methods that need large numbers of people, these methods rely on real field experience and deep knowledge. The experts are picked carefully to make sure they have years of direct work in the field. Any doubt or personal bias in their answers is handled using fuzzy logic, which turns their words into clear, usable numbers [14, 15]. This selection criterion follows established practice for identifying individuals with sufficient practical and domain-specific experience to serve as experts in decision-making studies [16, 17]. Data were collected using structured questionnaires distributed via Google Forms, supported by guided interview sessions. The questionnaire comprised two sections: pairwise comparisons of the six determinants for the Fuzzy AHP analysis, and influence evaluations of the determinants for the Fuzzy DEMATEL analysis, using the linguistic scales shown in Table 2 and Table 3.

Table 2. Fuzzy Linguistic Scale for Fuzzy AHP

Linguistic Term	Triangular Fuzzy Number
Equal Importance	(1,1,1)
Moderate Importance	(2,3,4)
Strong Importance	(4,5,6)
Very Strong Importance	(6,7,8)
Extreme Importance	(8,9,9)

Table 3. Fuzzy Linguistic Scale for Fuzzy DEMATEL

Linguistic Term	Influence Score	Triangular Fuzzy Number
No Influence	0	(0,0,0.25)
Low Influence	1	(0,0.25,0.5)
Medium Influence	2	(0.25,0.5,0.75)
High Influence	3	(0.5,0.75,1.00)
Very high Influence	4	(0.75,1.00,1.00)

Fuzzy AHP Method

Step 1: Construct the fuzzy pairwise comparison matrix.

Each expert compares every determinant against every other determinant using the linguistic scale in Table 2, forming a matrix A (1), where (2) represents the fuzzy importance of determinant i relative to determinant j.

$$\tilde{A} = \left[\tilde{a}_{ij} \right] \quad (1)$$

$$\tilde{a}_{ij} = \left(l_{ij}, m_{ij}, u_{ij} \right) \quad (2)$$

Step 2: Aggregate expert judgments.

The individual matrices are combined into a single aggregated matrix using the geometric mean method:

$$\tilde{a}_{ij} = \left(\left(\prod_{k=1}^{K} l_{ij}^{k} \right)^{\frac{1}{K}}, \left(\prod_{k=1}^{K} m_{ij}^{k} \right)^{\frac{1}{K}}, \left(\prod_{k=1}^{K} u_{ij}^{k} \right)^{\frac{1}{K}} \right) \quad (3)$$

Where K is the number of experts, l,m,u is the lower, middle and upper values.

Step 3: Calculate the fuzzy geometric mean.

$$\tilde{g}_{j} = \left(\prod_{j=1}^{n} \tilde{a}_{ij} \right)^{\frac{1}{n}} \quad (4)$$

Step 4: Calculate the fuzzy weights.

$$\tilde{w}_{j} = \tilde{g}_{j} \otimes \left(\sum_{j=1}^{n} \tilde{g}_{j} \right)^{-1} \quad (5)$$

Step 5: Defuzzify and normalize weights.

The fuzzy weights are defuzzified using the Center of Area (COA) method, then normalized:

$$BNP = \frac{l+m+u}{3} \quad (6)$$

$$w_i = \frac{BNP}{\sum_{i=1}^{n} BNP} \quad (7)$$

Where BNP = Best Non-Fuzzy Performance Value and w_i is normalized weight of factor i.

Step 6: Rank the determinants according to their normalized weights.

Fuzzy DEMATEL Method

Step 1: Construct the initial direct-relation matrix.

Experts evaluate the degree of influence of each determinant on every determinant using Table 3, forming

$$Z = \left[Z_{ij} \right]$$
$$i, j = 1, 2, ..., n \quad (8)$$

Step 2: Aggregate expert judgments using the average method.

$$\tilde{z}_{ij} = \frac{\tilde{z}_{ij}^{1} + \tilde{z}_{ij}^{2} + ... + \tilde{z}_{ij}^{K}}{K} \quad (9)$$

Where z_{ij} represents the influence of factor i on factor and j and K is the number of experts.

Step 3: Defuzzify the direct-relation matrix using the Converting Fuzzy Data into Crisp Scores (CFCS) method [11] to obtain a crisp direct-relation matrix A.

$$\tilde{z}_{ij} = (l_{ij}, m_{ij}, u_{ij}) \quad (10)$$

The normalization fuzzy values

$$x_l = \frac{l_{ij} - \min(l_{ij})}{\Delta} \quad (11)$$

$$x_m = \frac{m_{ij} - \min(l_{ij})}{\Delta} \quad (12)$$

$$x_u = \frac{u_{ij} - \min(l_{ij})}{\Delta} \quad (13)$$

$$\Delta = \max(u_{ij}) - \min(l_{ij}) \quad (14)$$

The left normalized value (XLS) and right normalized value (XRS) using

$$XLS = \frac{x_m}{1 + x_m - x_l} \quad (15)$$

$$XRS = \frac{x_u}{1 + x_u - x_m} \quad (16)$$

Crisp value obtained using

$$x_{ij} = \frac{xls(1 - xls) + xrs^2}{1 - xls + xrs} \quad (17)$$

The final defuzzify crisp value calculated using

$$\tilde{w}_{ij} = \min(l_{ij}) + (x_{ij} \times \Delta) \quad (18)$$

Step 4: Normalize the Direct-Relation Matrix:

$$\lambda = \min\left[\frac{1}{\max_i \sum_{j=1}^{n} a_{ij}}, \frac{1}{\max_j \sum_{i=1}^{n} a_{ij}}\right] \quad (19)$$

$$D = \lambda A \quad (20)$$

Step 5: Calculate the Total Relation Matrix:

$$\tilde{T} = D(I - D)^{-1} \quad (21)$$

Step 6: Determine Cause-Effect Relationship

$$R_i = \sum_{i=1}^{n} \tilde{t}_{ij} \quad (22)$$

$$C_j = \sum_{j=1}^{n} \tilde{t}_{ij} \quad (23)$$

$$R_i + C_j \quad (24)$$

$$R_i - C_j \quad (25)$$

Determinants with $R_i - C_j > 0$ are classified as cause factors, and those with $R_i - C_j < 0$ as effect factors.

IMPLEMENTATION

Data were collected from six experts and analysed using Microsoft Excel to apply the Fuzzy AHP and Fuzzy DEMATEL methods described in Section 2.

Fuzzy AHP Implementation

The initial steps in the implementation of FAHP generated the following fuzzy pairwise comparison matrix for each determinant (Table 4). The focus is on six determinants (F1-F6) and involves six experts (E1-E6).

Table 4. Fuzzy Pairwise Comparison matrix of the factors.

Expert 1						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(1,1,1)	(1/9,1/9,1/8)	(8,9,9)	(4,5,6)	(1/8,1/7,1/6)	(1/9,1/9,1/8)
F2	(8,9,9)	(1,1,1)	(8,9,9)	(8,9,9)	(4,5,6)	(1,1,1)
F3	(1/9,1/9,1/8)	(1/9,1/9,1/8)	(1,1,1)	(1/9,1/9,1/8)	(1/8,1/7,1/6)	(1/9,1/9,1/8)
F4	(1/6,1/5,1/4)	(1/9,1/9,1/8)	(8,9,9)	(1,1,1)	(1/4,1/3,1/2)	(1/6,1/5,1/4)
F5	(6,7,8)	(1/6,1/5,1/4)	(6,7,8)	(2,3,4)	(1,1,1)	(2,3,4)
F6	(8,9,9)	(1,1,1)	(8,9,9)	(4,5,6)	(1/4,1/3,1/2)	(1,1,1)
Expert 2						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(1,1,1)	(1,1,1)	(8,9,9)	(2,3,4)	(4,5,6)	(6,7,8)
F2	(1,1,1)	(1,1,1)	(8,9,9)	(6,7,8)	(6,7,8)	(6,7,8)
F3	(1/9,1/9,1/8)	(1/9,1/9,1/8)	(1,1,1)	(1/8,1/7,1/6)	(1/6,1/5,1/4)	(1/8,1/7,1/6)
F4	(1/4,1/3,1/2)	(1/8,1/7,1/6)	(6,7,8)	(1,1,1)	(1/8,1/7,1/6)	(1/8,1/7,1/6)
F5	(1/6,1/5,1/4)	(1/8,1/7,1/6)	(4,5,6)	(6,7,8)	(1,1,1)	(1/8,1/7,1/6)
F6	(1/8,1/7,1/6)	(1/8,1/7,1/6)	(6,7,8)	(6,7,8)	(6,7,8)	(1,1,1)
Expert 3						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(1,1,1)	(1/8,1/7,1/6)	(6,7,8)	(6,7,8)	(1/8,1/7,1/6)	(1/8,1/7,1/6)
F2	(6,7,8)	(1,1,1)	(6,7,8)	(6,7,8)	(1/8,1/7,1/6)	(6,7,8)
F3	(1/8,1/7,1/6)	(1/8,1/7,1/6)	(1,1,1)	(1/8,1/7,1/6)	(1/8,1/7,1/6)	(1/8,1/7,1/6)

F4	(1/8,1/7,1/6)	(1/8,1/7,1/6)	(6,7,8)	(1,1,1)	(1/8,1/7,1/6)	(1/8,1/7,1/6)
F5	(6,7,8)	(6,7,8)	(6,7,8)	(6,7,8)	(1,1,1)	(6,7,8)
F6	(6,7,8)	(1/8,1/7,1/6)	(6,7,8)	(6,7,8)	(1/8,1/7,1/6)	(1,1,1)
Expert 4						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(1,1,1)	(8,9,9)	(6,7,8)	(4,5,6)	(8,9,9)	(6,7,8)
F2	(1/9,1/9,1/8)	(1,1,1)	(8,9,9)	(6,7,8)	(4,5,6)	(8,9,9)
F3	(1/8,1/7,1/6)	(1/9,1/9,1/8)	(1,1,1)	(8,9,9)	(6,7,8)	(1/8,1/7,1/6)
F4	(1/6,1/5,1/4)	(1/8,1/7,1/6)	(1/9,1/9,1/8)	(1,1,1)	(1/8,1/7,1/6)	(8,9,9)
F5	(1/9,1/9,1/8)	(1/6,1/5,1/4)	(1/8,1/7,1/6)	(6,7,8)	(1,1,1)	(1/8,1/7,1/6)
F6	(1/8,1/7,1/6)	(1/9,1/9,1/8)	(6,7,8)	(1/9,1/9,1/8)	(6,7,8)	(1,1,1)
Expert 5						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(1,1,1)	(1/6,1/5,1/4)	(1/6,1/5,1/4)	(1/8,1/7,1/6)	(1/6,1/5,1/4)	(1/8,1/7,1/6)
F2	(4,5,6)	(1,1,1)	(6,7,8)	(1/6,1/5,1/4)	(6,7,8)	(1/8,1/7,1/6)
F3	(4,5,6)	(1/8,1/7,1/6)	(1,1,1)	(1/6,1/5,1/4)	(1/6,1/5,1/4)	(1/6,1/5,1/4)
F4	(6,7,8)	(4,5,6)	(4,5,6)	(1,1,1)	(1/6,1/5,1/4)	(1/6,1/5,1/4)
F5	(4,5,6)	(1/8,1/7,1/6)	(4,5,6)	(4,5,6)	(1,1,1)	(1/8,1/7,1/6)
F6	(6,7,8)	(6,7,8)	(6,7,8)	(6,7,8)	(6,7,8)	(1,1,1)
Expert 6						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(1,1,1)	(1,1,1)	(1/8,1/7,1/6)	(1,1,1)	(1/9,1/9,1/8)	(1/9,1/9,1/8)
F2	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)
F3	(6,7,8)	(1,1,1)	(1,1,1)	(6,7,8)	(1/9,1/9,1/8)	(1/9,1/9,1/8)
F4	(1,1,1)	(1,1,1)	(1/8,1/7,1/6)	(1,1,1)	(1/8,1/7,1/6)	(1/8,1/7,1/6)
F5	(8,9,9)	(1,1,1)	(8,9,9)	(6,7,8)	(1,1,1)	(1/8,1/7,1/6)
F6	(8,9,9)	(1,1,1)	(8,9,9)	(6,7,8)	(6,7,8)	(1,1,1)

Each expert compared the six determinants (F1-F6) using the linguistic terms in Table 2. Using Equation (3), the aggregation calculation for the lower value of the comparison between F1 and F2 across the six experts is shown below:

$$a_{F2}^{L} = (0.111 \times 1 \times 0.125 \times 8 \times 0.167 \times 1)^{\frac{1}{6}} = 0.51445$$

The same procedure was applied to all pairwise comparisons to obtain the complete aggregated fuzzy pairwise comparison matrix as presented in Table 5 below.

Table 5. Aggregated Fuzzy Pairwise Comparison matrix of the factors.

Factors	F1	F2	F3	F4	F5	F6
F1	(1,1,1)	(0.51445,0.55291, 0.60067)	(1.907,2.64361, 2.45031)	(1.69838,2.05392, 2.40267)	(0.45832, 0.52284, 0.60087)	(0.43664,0.48075, 0.55069)
F2	(1.66509,1.80831, 1.94416)	(1,1,1)	(5.13959,5.73879,6)	(2.57065,2.91806, 3.23774)	(2.03965, 2.36533, 2.69691)	(1.81712,1.99509, 2.14054)
F3	(0.40811,0.48696, 0.52491)	(0.16658,0.17422, 0.1947)	(1,1,1)	(0.24037,0.26581, 0.30906)	(0.25731 ,0.29322, 0.34691)	(0.12609,0.13898, 0.16218)

F4	(0.41662,0.48696, 0.58899)	(0.30881,0.34281, 0.38952)	(3.23774,3.76268, 4.16155)	(1,1,1)	(0.14725 ,0.1741, 0.21444)	(0.27534,0.31895, 0.37129)
F5	(1.665643,1.912612, 2.18225)	(0.3711765,0.422966, 0.490607)	(2.884499,3.411555, 3.889618)	(4.66063,5.746639, 6.793525)	(1,1,1)	(0.378271,0.454214, 0.540343)
F6	(1.817121,2.080777, 2.290954)	(0.46725,0.501398, 0.550688)	(6.172327,7.196558, 7.930813)	(2.695563, 3.136362, 3.634241)	(1.853144, 2.203072, 2.644485)	(1,1,1)

Using Equation (4), the lower geometric mean for F1 was calculated as 0.83273, giving a total geometric mean sum across all factors of (6.63962, 7.44147, 8.19453). Applying Equation (5), the fuzzy weight for F1 was obtained as (0.10162, 0.12822, 0.15461). Defuzzifying using Equation (6) gave BNP (F1) = 0.12815, which normalized to a final weight of 0.12628. The same calculations were repeated for all six determinants, producing the results summarized in Table 6.

Table 6. Fuzzy AHP Weight Results

Determinant	**Weight**	**Rank**
Financial Resources (F2)	0.30576	1
Entrepreneurial Skills (F6)	0.26020	2
Operational Challenges (F5)	0.18779	3
Time Management (F1)	0.12628	4
Customer Behaviour (F4)	0.07773	5
Competition (F3)	0.04223	6

Fuzzy DEMATEL Implementation

Each expert evaluated the degree of influence between all pairs of determinants using the linguistic scale shown in Table 3. Consequently, the aggregated matrix was obtained using Equation (9), The fuzzy-direct relation matrix and the aggregated fuzzy direct-relation matrix are presented in Table 7 and 8 respectively.

Table 7. Fuzzy Direct-Relation Matrix of the factors.

Expert 1						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(0,0,0)	(0,0.25,0.5)	(0.25,0.5,0.75)	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)
F2	(0.5,0.75,1)	(0,0,0)	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)
F3	(0.25,0.5,0.75)	(0.5,0.75,1)	(0,0,0)	(0.5,0.75,1)	(0.75,1,1)	(0.5,0.75,1)
F4	(0.25,0.5,0.75)	(0.75,1,1)	(0.75,1,1)	(0,0,0)	(0.25,0.5,0.75)	(0.5,0.75,1)
F5	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0,0,0)	(0.5,0.75,1)
F6	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0,0,0)
Expert 2						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(0,0,0)	(0.75,1,1)	(0.5,0.75,1)	(0.75,1,1)	(0.5,0.75,1)	(0.75,1,1)
F2	(0.75,1,1)	(0,0,0)	(0.5,0.75,1)	(0.75,1,1)	(0.5,0.75,1)	(0.5,0.75,1)
F3	(0.5,0.75,1)	(0.5,0.75,1)	(0,0,0)	(0.5,0.75,1)	(0.5,0.75,1)	(0.75,1,1)
F4	(0.75,1,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0,0,0)	(0.5,0.75,1)	(0.5,0.75,1)
F5	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0,0,0)	(0.75,1,1)
F6	(0.5,0.75,1)	(0.75,1,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0,0,0)

Expert 3						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(0,0,0)	(0.25,0.5.75)	(0.5,0.75,1)	(0,0.25,0.5)	(0.75,1,1)	(0,0.25,0.5)
F2	(0.25,0.5,0.75)	(0,0,0)	(0.5,0.75,1)	(0,0.25,0.5)	(0.75,1,1)	(0.25,0.5,0.75)
F3	(0.25,0.5,0.75)	(0.5,0.75,1)	(0,0,0)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)
F4	(0.5,0.75,1)	(0.5,0.75,1)	(0,0.25,0.5)	(0,0,0)	(0.5,0.75,1)	(0,0.25,0.5)
F5	(0.75,1,1)	(0.75,1,1)	(0.25,0.5,0.75)	(0,0.25,0.5)	(0,0,0)	(0.5,0.75,1)
F6	(0.5,0.75,1)	(0.5,0.75,1)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0,0,0)
Expert 4						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(0,0,0)	(0.5,0.75,1)	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)	(0.75,1,1)
F2	(0.25,0.5,0.75)	(0,0,0)	(0.5,0.75,1)	(0.5,0.75,1)	(0.75,1,1)	(0.75,1,1)
F3	(0.5,0.75,1)	(0.75,1,1)	(0,0,0)	(0.5,0.75,1)	(0.75,1,1)	(0.75,1,1)
F4	(0.75,1,1)	(0.5,0.75,1)	(0.75,1,1)	(0,0,0)	(0.75,1,1)	(0.75,1,1)
F5	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0.25,0.5,0.75)	(0,0,0)	(0.75,1,1)
F6	(0.75,1,1)	(0.5,0.75,1)	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0,0,0)
Expert 5						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(0,0,0)	(0,0.25,0.5)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0.25,0.5,0.75)
F2	(0,0.25,0.5)	(0,0,0)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0,0.25,0.5)
F3	(0,0.25,0.5)	(0,0.25,0.5)	(0,0,0)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)
F4	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0.25,0.5,0.75)	(0,0,0)	(0.25,0.5,0.75)	(0.25,0.5,0.75)
F5	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0,0,0)	(0.25,0.5,0.75)
F6	(0.5,0.75,1)	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.5,0.75,1)	(0,0,0)
Expert 6						
Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(0,0,0)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0.5,0.75,1)	(0.75,1,1)	(0.75,1,1)
F2	(0.25,0.5,0.75)	(0,0,0)	(0.75,1,1)	(0.5,0.75,1)	(0.75,1,1)	(0.5,0.75,1)
F3	(0.5,0.75,1)	(0.25,0.5,0.75)	(0,0,0)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)
F4	(0.5,0.75,1)	(0.25,0.5,0.75)	(0.5,0.75,1)	(0,0,0)	(0.25,0.5,0.75)	(0.25,0.5,0.75)
F5	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0,0,0)	(0.75,1,1)
F6	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0.75,1,1)	(0,0,0)

Table 8. Aggregated Fuzzy Direct-Relation Matrix of the factors.

Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	(0,0,0)	(0.291667,0.541667, 0.75)	(0.458333, 0.708333,	(0.5,0.75,0.875)	(0.625,0.875,1)	(0.5,0.75.0.875)

			0.916667)			
F2	(0.333333, 0.583333, 0.791667)	(0,0,0)	(0.583333 ,0.833333,1)	(0.5,0.75,0.916667)	(0.666667,0.916667,1)	(0.416667,0.833333, 0.875)
F3	(0.333333, 0.541667, 0.791667)	(0.416667,0.666667, 0.875)	(0,0,0)	(0.5,0.75,1)	(0.583333,0.833333,1)	(0.583333,0.833333, 1)
F4	(0.5,0.75, 0.916667)	(0.458333,0.708333, 0.916667)	(0.458333 ,0.708333, 0.875)	(0,0,0)	(0.416667,0.666667, 0.875)	(0.375,0.625, 0.833333)
F5	(0.666667 ,0.916667,1)	(0.666667,0.916667,1)	(0.541667, 0.791667, 0.958333)	(0.458333,0.708333, 0.875)	(0,0,0)	(0.583333,0.833333, 0.958333)
F6	(0.625,0.875,1)	(0.666667,0.916667,1)	(0.625,0.875, 0.958333)	(0.583333,0.833333, 0.958333)	(0.583333,0.833333,1)	(0,0,0)

For the defuzzification step, the CFCS method were applied. The left normalized value was calculated as XLS = 0.433333, the right normalized value as XRS = 0.620690, giving a crisp value of 0.531274. The same procedure was repeated for all elements, producing the crisp direct-relation matrix, which was then normalized using Equation (20) and used to compute the total relation matrix T using Equation (8). The Crisp-Direct Relation Matrix, the Normalized Value Matrix and the Total Relation Matrix (T) were presented in Table 9, 10 and 11 below.

Table 9. Crisp Direct-Relation Matrix

Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**Row Sum**
F1	0	0.53127	0.68884	0.7174	0.84123	0.7174	3.49614
F2	0.57058	0	0.80381	0.72306	0.88055	0.64936	3.62737
F3	0.54718	0.64936	0	0.73333	0.80381	0.80381	3.53749
F4	0.72306	0.68884	0.68286	0	0.64936	0.60995	3.35407
F5	0.88055	0.88055	0.76338	0.68286	0	0.79977	4.00711
F6	0.84123	0.88055	0.83786	0.79977	0.80381	0	4.16321
Column Sum	3.5626	3.63057	3.77675	3.65643	3.97876	3.58029	

Table 10. Normalized Direct-Relation Matrix

Factor	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	0	0.12761	0.16546	0.17232	0.20206	0.17232
F2	0.13705	0	0.19307	0.17368	0.21151	0.15598
F3	0.13143	0.15598	0	0.17615	0.19307	0.19307
F4	0.17368	0.16546	0.16402	0	0.15598	0.14651
F5	0.21151	0.21151	0.18336	0.16402	0	0.1921
F6	0.20206	0.21151	0.20125	0.1921	0.19307	0

Table 11. Total Relation Matrix (T)

Factor	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
F1	1.11838	1.25093	1.31369	1.28591	1.39196	1.26959
F2	1.27215	1.17181	1.37001	1.32157	1.43652	1.29206
F3	1.24844	1.28663	1.18664	1.30278	1.40037	1.29788
F4	1.21921	1.23128	1.26553	1.09323	1.31024	1.20486
F5	1.42609	1.44748	1.46851	1.41752	1.37283	1.41856
F6	1.45792	1.48706	1.52193	1.47735	1.57676	1.29636

The final step in Fuzzy DEMATEL Method is the determination of cause-and-effect relationship. The row sum, column sum, and resulting prominence and relation values for each determinant are presented in Table

12. For example, for F1, $R = 7.63046, C = 7.7422,$ giving $R + C = 15.3727$ and $R - C = -0.11174$, classifying F1 as an effect factor.

Table 12. Fuzzy DEMATEL Cause-Effect Results

Determinant	R	C	$R + C$	$R - C$	**Group**
Time Management (F1)	7.63046	7.7422	15.3727	-0.11174	Effect
Financial Resources (F2)	7.86412	7.8752	15.7393	-0.01108	Effect
Competition (F3)	7.72275	8.12632	15.8491	-0.40357	Effect
Customer Behaviour (F4)	7.32436	7.89835	15.2227	-0.57399	Effect
Operational Challenges (F5)	8.55100	8.48868	17.0397	0.06232	Cause
Entrepreneurial Skills (F6)	8.81738	7.77932	16.5967	1.03807	Cause

RESULTS AND DISCUSSION

Fuzzy AHP Ranking

As shown in Table 6, financial resources (F2) recorded the highest weight of 0.30576, indicating that experts considered it the most important determinant of student entrepreneurship. This is consistent with prior findings that limited capital, cash flow constraints, and rising operating costs are major challenges affecting entrepreneurial development [18], as many students operate their businesses with limited capital while relying on personal savings or small-scale income. Entrepreneurial skills (F6) ranked second, supporting evidence that entrepreneurial competencies and self-efficacy significantly contribute to students' entrepreneurial development [19]. Competition (F3) obtained the lowest weight of 0.04223, suggesting that student business performance depends more on entrepreneurs' internal capabilities than on market competition itself [20].

Fuzzy DEMATEL Cause-Effect Analysis

As shown in Table 12, entrepreneurial skills (F6) and operational challenges (F5) were classified as cause factors, with F6 recording the highest positive $R - C$ value of 1.038, indicating it is the strongest driving factor in the system. This is consistent with prior findings identifying entrepreneurial skills and operational challenges as key drivers of entrepreneurial performance [21, 22]. Meanwhile, time management (F1), financial resources (F2), competition (F3), and customer behaviour (F4) were classified as effect factors, indicating that these determinants are more likely to be shaped by the two cause factors than to influence others directly. This suggests that interventions targeting entrepreneurial skills and operational support may have a greater downstream effect on student entrepreneurship outcomes than addressing effect-group factors in isolation.

CONCLUSION

This study successfully applied an integrated Fuzzy AHP-DEMATEL approach to evaluate the determinants influencing student entrepreneurship among student entrepreneurs. Financial resources, entrepreneurial skills, and operational challenges emerged as the most important determinants by weight, while entrepreneurial skills and operational challenges were identified as the underlying cause factors driving the remaining determinants. These findings provide practical guidance for students, educators, and university administrators in prioritising support strategies to strengthen student entrepreneurship.

As for recommendations, future researchers are encouraged to include the different number of experts or involve experts from different universities and business backgrounds to obtain more comprehensive findings. Other decision-making methods such as ANP, TOPSIS, or PROMETHEE may also be explored to refine the evaluation of student entrepreneurship determinants.

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