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Research Article

Developing a Risk Index for Start-Up Businesses in SMEs Using the Fuzzy Delphi Method (FDM)

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Abstract. The growth of business start-ups, especially small and medium-sized enterprises, has grown due to their importance in driving economic development and creating jobs. However, many people who establish businesses struggle to sustain them beyond five years and eventually close them down. The challenges entrepreneurs face during their journeys are caused by the different risks and obstacles they face. In this context, effective management of risks is necessary for entrepreneurs to recognize and reduce such risks. This research article aims to construct a risk index for start-up businesses in SMEs by achieving expert consensus on major risk elements during start-up stages using the Fuzzy Delphi Method (FDM). The study employed a questionnaire developed through semi-structured interviews with entrepreneurs. Twenty one entrepreneurs from three industries were selected as a sample for this study. Analysing data using Microsoft Excel FDM showed four major risk factors affecting start-up businesses in small and medium-sized companies: Strategic Risk, Entrepreneurial Traits, Financial Risk, and Operational Risk. Using these factors, it is possible to generate a risk model for start-up firms within SMEs, which will serve as a guideline for entrepreneurs and other stakeholders in Malaysia. In addition, this study also assigned a weightage for every risk factor based on their priority. Lastly, using the weightage and basic formulation of the composite index, a general mathematical formulation of the Enterprise Risk Management Index was developed for start-up businesses in SMEs. Therefore, it will reduce the failure rate of start-up enterprises and increase the possibility of their success.

Keywords. Fuzzy Delphi Method (FDM), Risk factors, Composite index, SMEs, Weightage
Mathematics Subject Classification (2020). 00A05, 00A06, 00A71

1. Introduction

The Malaysian government promotes entrepreneurship among Malaysians, especially the younger generation, by providing financial support and organizing entrepreneurship programs. SMEs also contribute to economic growth (Rahlin *et al*. [36]) and employment generation (Toku *et al*. [42]). The Gross Domestic Product (GDP) contribution from Malaysia's SME sector was 5.8 percent in 2019, an increase of 6.2 percent from 2018. Besides, SMEs encounter issues of unemployment and improve their living style (Lim and Teoh [26]). Based on data from the Department of Statistics Malaysia (2020), SMEs' employment performance increased by 3.0% in 2019 compared to the 2018 figure, which increased by about 3.2%, with their share of the workforce rising from about 48.0% in the previous year to about 48.4% (Ministry of Entrepreneur Development and Cooperatives [31]).

Nevertheless, many entrepreneurs suffer to remain viable in the initial five years of business operation (Lim and Teoh [26]). The start-up stage is one of the stages in life cycle of business. Entrepreneurs do not focus on harvesting at the start-up stage because it involves risks and the possibility of failure (da Silva Piñeiro *et al*. [40]). In accordance with Weking *et al*. [45], the failure rate in start-up stages could vary from 50% to 83%, and some estimates even reach 90%. A major reason is that these ventures are highly risky since they are limited in resources, lack market experience, and deal with a rapidly changing environment. In addition, start-up businesses are at risk of financial loss since they are not familiar enough with their own businesses to make informed decisions (Rahman *et al*. [37]). For the sustainability and success of start-ups, it is essential that they develop a proper risk management strategy that assists in identifying, assessing, and prioritizing risks.

Enterprise Risk Management (ERM) is one of the approaches in risk management that simultaneously manage all risks faced by entrepreneurs rather than traditional risk management that deals with them individually (Gordon *et al*. [14], and Naseem *et al*. [34]). It is crucial to implement practices of risk management as well as ERM in start-up SMEs since they assist entrepreneurs or managers in managing the risks and problems that arise in their businesses. Prior researchers showed ERM could serve as an efficient firm performance measurement. Furthermore, some researchers have even included an index in their ERM to measure firms' risk management effectiveness. However, this method cannot be used by start-up companies because they are limited in terms of resources. At this point, entrepreneurs should focus more on managing risks than measuring performance. Suib *et al*. [41] employed the Fuzzy Delphi Method (FDM) to identify and evaluate weights of significant risk factors in special education mathematics to create a comprehensive risk management index.

This study focused on developing a risk model for business start-ups in SMEs and evaluating their weightage using the FDM approach. The findings will then be used to construct an ERM index for start-up businesses in SMEs. This formulation of an ERM index can be an alternative measurement tool that can help entrepreneurs measure their level of risk and readiness to start a new business.

2. Literature Review

Risk management employs several strategies and tools to prevent direct and indirect losses. These strategies emphasize its ability to react to environmental changes. Different types and objectives of business require different approaches to risk management (Zoghi [50]). According to Hamir and Sum [16], risk management is an approach that can be customized to meet the organization's specific needs; it is not a single, universal technique. Basically, risk management processes involved identification of risks, estimation of risks, evaluation of probability, measurement of potential impacts of events, reduction of risks, and elimination their effect while investing as little resources as possible (Hamir and Sum [17]). ISO 31000 risk management defines *risk assessment* as identifying, analyzing, and evaluating risks. Risk management consists of two approaches: traditional risk management, also referred to as silo-based risk management, and enterprise risk management (Ade *et al*. [1], and Gordon *et al*. [14]).

2.1 Enterprise Risk Management (ERM)

One of the most innovative and complicated areas of risk management is Enterprise Risk Management (ERM) (Ferreira de Araújo Lima *et al*. [11]). It is used in the enterprise business to recognize and handle every possible occurrence that may impact the company's performance and give a reasonable expectation that the company will reach its goals. In contrast with traditional risk management approach, ERM, through a holistic approach, help entrepreneurs to handle and manage risks and opportunities simultaneously and efficiently (Gordon *et al*. [14]). So, with ERM, strategic, operational, financial, hazard, and other organizational risks are combined and addressed all together.

ERM is implemented to evaluate the organizational performance of an organization (Ade *et al*. [1], Ferreira de Araújo Lima *et al*. [11], Rehman and Anwar [38], Yakob *et al*. [47]). Rehman and Anwar (2019) [38] investigated the function of ERM as a connector between company strategy and SME success. The study discovered that business management influences SME performance, with ERM as a moderator; however, ERM has a modest impact. Thus, the study suggests that senior management must take strategic action to implement effective and suitable ERM processes that boost profitability (Rehman and Anwar [38]).

Other previous studies found that ERM techniques significantly contribute to SMEs' competitive advantage and performance. The study found that competitive advantage moderates the relationship between ERM practices and SME performance. In addition, knowledge of financial management moderates the interaction involving ERM practices and competitive advantage (Yang *et al*. [48]). The findings of these two studies reveal the significance of managerial leadership, financial literacy, and competitive advantage in ensuring the effectiveness of ERM practices and finally contributing to improved SME performance.

Bensaada and Taghezout [6] designed an ERM system for SMEs comprising the following five elements: foundations and context, modeling and evaluation, reaction and treatment, monitoring and review, and communication and information (Hamir and Sum [17]). The development of an ERM system aims to help SMEs engage in ERM with minimum resource investment. It has been proven that ERM processes need to be user-friendly, accessible, and tailored to different organizational needs (Bensaada and Taghezout [6]).

2.2 Application of Index in Risk Management

Previous researchers have used integration mathematical approaches to enhance and refine existing models. According to Hadi *et al*. [15], the index is a valuable systematic measure of business development success that businesses use to monitor their innovation. Indexes are also used in risk management to measure performance, such as the SME Worker Affective (SWA) Index (Ushada *et al*. [43]), Human Development Index (HDI) (Aydogan [5]), Tourism Sustainability Index (TSI) (Marchi *et al*. [28]), and European Performance Satisfaction Index (Ghanian *et al*. [12]). In ERM, the index is used to quantify the connection between ERM and company value (Gordon *et al*. [14], and Naseem *et al*. [34]).

Naseem *et al*. [34] investigated the function of ERM as the intermediary of corporate social responsibility and business performance. The previous study measured a firm's ERM using the ERM Index (ERMI) created by Gordon *et al*. [14]. The goal of the ERMI is to integrate the attainment of the four ERM goals outlined by the Committee of Sponsoring Organizations of the Treadway Commission (COSO) into a single metric. The objectives include strategy, operations, reporting, and compliance. The equation of ERMI used by these two previous studies is shown in equation (2.1):

$$\text{ERMI} = \sum_{k=1}^{2} \text{Strategy}_k + \sum_{k=1}^{2} \text{Operation}_k + \sum_{k=1}^{2} \text{Reporting}_k + \sum_{k=1}^{2} \text{Compliance}_k \,. \tag{2.1}$$

This formulation used two indicators to measure the achievement of each objective. According to Gordon *et al*. [14] and Naseem *et al*. [34], this formulation of ERMI is a reasonable measurement of the effectiveness of ERM. The researchers believed that ERMI could be an effective measurement tool for ERM implementation. ERMI formulation developed by using composite index that can combine all the component indices into one value. According to the researchers, this approach needs to determine the combination weights by subjective or objective weighting methods. The previous study developed a new method that used a combination of these two methods: data and expert opinion (Chen *et al*. [8]).

2.3 Fuzzy Delphi Method (FDM)

The Fuzzy Delphi Method (FDM) effectively achieves experts' agreement or consensus in determining and validating model elements. The approach is widely used in various fields, including entrepreneurship (Kor *et al*. [24], Kumar *et al*. [25], and Musa *et al*. [33]). In a previous study by Mahdiraji *et al*. [27], FDM was utilized to screen the critical innovation factors for efficient crowdfunding for entrepreneurial SMEs. The study used a Seven-Likert scale questionnaire to gather experts' opinions. The questionnaire items were identified through a literature review (Mahdiraji *et al*. [27]). Other previous researchers also used a literature review as the first step in developing the elements of the questionnaires. Then, they used FDM to revalidate the aspects that influence the involvement of women in the Entrepreneurship Scale (Musa *et al*. [33]).

Kumar *et al*. [25] also used literature review and FDM in the first stage of their study to identify and finalise the potential risks in the green supply chain in the pharmaceutical industry. Then, the researchers used fuzzy AHP to prioritize the risks. Previous researchers applied a two-phase approach to determine career planning capabilities in job-based learning. First, the study used document analysis and structured interviews to develop the expert

questionnaire. They then distributed the expert questionnaire to 16 experts to get a consensus. Using FDM, researchers also get priority for all elements (Marwan and Ali [29]). Based on prior research, FDM is an appropriate strategy for this study to determine relevant risk variables and weightage based on expert opinion.

3. Methodology

This study has implemented the fuzzy Delphi Method (FDM) to establish an expert agreement on the risk variables associated with small—and medium-sized company start-ups. This approach is more preferred than the Delphi method because its efficiency in manage questionnaires at a lower cost (Jamil *et al*. [21]). This study used quantitative analysis, which facilitates the interpretation of final results obtained from qualitative studies and enables the conversion of qualitative values into quantitative values (Alfawaz and Alshehri [2]). A risk index for start-up businesses in SMEs can be developed based on the risk model and weightage using the basic formulation of a composite index.

3.1 Instrument

The items in the questionnaire used in this study were constructed to address five factors found through semi-structured interviews conducted during the first phase of research (Fauzi *et al*. [9, 10]). Experts were asked to complete a seven-point questionnaire to obtain consensus on the items. The seven-point score was chosen because it provides greater precision and accuracy in the results. The Likert scale is used to measure attitudes, opinions, and perceptions of individuals or groups of people (Iskamto *et al*. [20]).

3.2 Respondents

According to Ridhuan *et al*. [39], the minimum sample of experts for FDM is 10, and the maximum is 50 experts. Thus, about twenty one experts among entrepreneurs from East Coast Malaysia was chosen to answered the questionnaires. The study selected all experts by using a purposive sampling approach. The experts were entrepreneurs from three industries: seven from the traditional food industry, seven from the coffee industry, and seven from the batik industry, with more than five years of experience in their respective fields. Marwan and Ali [29] suggested that the invited experts should have a minimum of 5 years of work experience in their industry to gain a wide range of diverse experiences and views on that field.

3.3 Data Analysis Procedure

This study utilized a formulated version of Excel created by Ridhuan *et al*. [39] to input the collected information and obtain FDM results. Experts responded to a seven-point Likert scale questionnaire, which was then converted into a fuzzy scale for analysis. Table 1 illustrates the process of transforming the seven-point Likert scale into a seven-point fuzzy score based on the level of consensus among the experts for each factor.

FDM consists of triangular numbers and fuzzy scores or evaluations. Two necessary conditions for FDM are Triangular Fuzzy Numbers and a Fuzzy Evaluation Process.

(1) *Triangular Fuzzy Number* — the average value of fuzzy numbers

Table 1. 7-Point fuzzy scale (Source: Ridhuan *et al*. [39])

Likert scale	Level of agreement	Fuzzy scale
7	Extremely Agree	(0.9, 1.0, 1.0)
6	Very Agree	(0.7, 0.9, 1.0)
5	Agree	(0.5, 0.7, 0.9)
4	Moderate Agree	(0.3, 0.5, 0.7)
3	Disagree	(0.1, 0.3, 0.5)
2	Very Disagree	(0.0, 0.1, 0.3)
1	Extremely Disagree	(0.0, 0.0, 0.1)

(i) The threshold value, d must be less or equal to 0.2 ($d \leq 0.2$):

$$d(m,n) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]},$$

where m_1 = the minimum value, m_2 = the reasonable value, m_3 = the maximum value.

(ii) The expert group agreement must be more or equal to 75% (expert consensus $\geq 75\%$).

(2) *Fuzzy Evaluation Process* — the process of accepting and ranking factors

The fuzzy score, $A_{\max}$ must be more or equal to α-cut 0.5 ($A_{\max} \geq 0.5$)

$$A_{\max} = \frac{1}{3} \times (m_1 + m_2 + m_3).$$

4. Results and Discussion

Table 2 summarizes the risk components for business start-ups in SMEs identified during the first analysis, which involved semi-structured interviews conducted among entrepreneurs from three industries.

Table 2. Risk Factors for start-up businesses in SMEs (Source: Fauzi *et al*. [9, 10])

Item label	Risk factors
1	Entrepreneurial Traits
2	Financial Risk
3	Operational Risk
4	Political Risk
5	Strategic Risk

FDM has prerequisites to meet before accepting risks. The threshold value, d must be less than 0.2, the experts' agreement should be greater than 75%, and the Fuzzy Score, $A_{\max}$ should be larger or equal to 0.5. Table 3 illustrates the results of the summarization of FDM analysis result.

Table 3. Summarization of FDM analysis result (Source: Author's elaboration - based on the result of formulated MICROSOFT EXCEL)

Risk factors	Condition of triangular fuzzy numbers		Condition of defuzzification process	Expert consensus
	Threshold value ($d < 0.2$)	Percentage of experts group consensus (%) (expert consensus ≥ 75%)	Fuzzy score ($A_{\max} \geq 0.5$)	
Entrepreneurial Traits	0.158	95.2%	0.870	Accepted
Financial Risk	0.193	90.5%	0.835	Accepted
Operational Risk	0.203	90.5%	0.816	Accepted
Political Risk	0.386	38.10%	0.663	Rejected
Strategic Risk	0.205	85.71%	0.838	Accepted

Result from Table 3 indicates that there are four risk factors are accepted by the experts which are Entrepreneurial Traits, Financial Risk, Operational Risk, and Strategic Risk. The percentage of expert consensus for Entrepreneurial Traits is the highest, at 95.2%, with a d-value of 0.158. Meanwhile, Financial Risk and Operational Risk obtained the same percentage of expert group consensus which is 90.5%, with d-value of 0.193 and 0.203, respectively. The percentage of experts group consensus for Strategic Risk is 85.71% with a d-value of 0.205. It has resulted in Political Risk being rejected as one of the risk factors of business start-ups in SMEs based on FDM analysis. It is because the percentage of experts group consensus for Political Risk is 38.10%, which is lower than 75%.

In addition, the FDM approach enabled us to evaluate the prioritization of the risk factors by getting the ranking of each element. The ranking is given based on value of Fuzzy Score (A). In this study, weightage for accepted risk factors will be assigned by ranking, with the highest-ranking factors receiving the most weight and the lowest-ranking factors receiving the least. Table 4 shows the weightage assigned based on the FDM analysis result. Based on Table 4, Entrepreneurial Traits is placed in first ranked, followed by Strategic Risk and Financial Risk. The last ranked based on FDM analysis results is Operational Risk.

Table 4. The weightage assigned based on FDM analysis result (Source: Author's elaboration - based on the result of formulated MICROSOFT EXCEL)

Risk factors	Fuzzy score ($A_{\max}$)	Position/Rank	Weightage
Entrepreneurial Traits	0.870	1	4
Financial Risk	0.835	3	2
Operational Risk	0.816	4	1
Strategic Risk	0.838	2	3

This study found that Entrepreneurial Traits is the most crucial risk elements for business start-ups in SMEs. This is in line with the qualitative result done in the first stage by Fauzi *et al*. [10]. The Entrepreneurial Traits is one of the essential component in entrepreneurial

process and play a central role in the formation of firms (Mishra and Zachary [32]). Several previous studies have also found that entrepreneurs need to possess entrepreneurial traits to be successful in their business ventures (Mashuda and Laily [30], and Vega-Gómez *et al*. [44]). One of the important characteristics of entrepreneurs is a willingness to take risks since the start-up business is exposed to various risks (Hoogendoorn *et al*. [19]). In addition, goal orientation and entrepreneurial competence is one of the biggest success factors for start-up businesses, according to Kim *et al*. [23]. Entrepreneurial traits can be measured by two variables: attitude and experience (Alfawaz and Aljedani [3]).

The experts in this study accepted financial risk as one of the risk factors. This is consistent with previous studies that agreed financial risk plays a crucial role in supporting start-up businesses (Weking *et al*. [45], and Zobnina [49]). Another element that accepted to be one of the risk components in business start-ups is Operational Risk. Brunner-Kirchmair and Wiener [7] also noted that Operational Risk can occur due to inadequate or failed internal processes, systems, or people or as a result of external forces. This is also supported by previous studies done by Hirawati and Sijabat [18], Oláh *et al*. [35], and Xu [46]. Last but not least, Strategic Risk is also accepted for the risk model of business start-ups in SMEs. Strategic Risk considered second crucial risk factor after Entrepreneurial Traits. It has been confirmed by a number of previous researchers who have studied Strategic Risk (Ambad *et al*. [4], Brunner-Kirchmair and Wiener [7], and Jobo and Phyllis [22]).

Furthermore, the study found that experts had rejected Political Risk as one of the risk elements in start-up business. This result contradicts to study by Fauzi *et al*. [10], which considered Political Risk as one of the risk elements in start-up businesses. The reason is that two participants during semi-structured interviews raised the topic of Political Risk. In addition, the ranking and weighting of the four accepted risk factors, as shown in Table 4, are equivalent to those of the qualitative study by Fauzi *et al*. [10]. Thus, the results strengthen the findings of this study. As studied by previous studies, the composite index can be integrated into ERM to measure performance (Gordon *et al*. [14], and Musa *et al*. [34]). Therefore, by using basic formulation of composite index and this risk model, a general risk index for start-up businesses in SMEs can be developed.

Composite index,

$$I^- = \frac{\sum(I_i W_i)}{\sum W_n},$$

where $i = 1,2,3,4$, $n = 1,2,3,4$, I = index number, W = weightage.

Assuming that $\sum W_i = W_i$.

This will give a composite index of the general function of the Enterprise Risk Management Index (ERMI) for start-up businesses in SMEs.

$$\begin{aligned} I^- &= \frac{\sum(I_i W_i)}{\sum W_n} \\ &= \frac{[W_1 \sum(ET)_i + W_2 \sum(SR)_i + W_3 \sum(FR)_i + W_4 \sum(OR)_i]}{[W_1 + W_2 + W_3 + W_4]} \\ &= \frac{[4\sum(ET)_i + 3\sum(SR)_i + 2\sum(FR)_i + 1\sum(OR)_i]}{[4+3+2+1]} \end{aligned}$$

$$= \frac{[4\sum(ET)_i + 3\sum(SR)_i + 2\sum(FR)_i + 1\sum(OR)_i]}{10}, \tag{4.1}$$

where:

ET is Entrepreneurial Traits, SR is Strategic Risk, FR is Financial Risk, OR is Operational Risk, $i = 1,2,3,4$.

5. Conclusions and Recommendation

In conclusion, the study has identified four significant risk factors that experts have agreed should be included in the risk model for start-up businesses: Entrepreneurial Traits, Strategic Risk, Financial Risk, and Operational Risk. Each of these factors plays a critical role in the success or failure of start-ups, particularly within the SME sector. The research has also determined the weightage for each risk factor, as detailed in Table 4, providing a quantitative basis for assessing the relative importance of each risk in the context of start-up enterprises. These findings provide the development of risk models along with their weighting, which is crucial for developing an innovative mathematical formulation of the ERM Index for start-up businesses in SMEs (Fauzi *et al*. [10], and Ghazali *et al*. [13]).

Besides, this model is relevant to entrepreneurs and stakeholders because it gives a structured framework for understanding and handling the risks involved in start-up business ventures. As a decision-making tool, this risk model can serve as a guideline for entrepreneurs, investors, and policy-makers. Also, this study provides a general formulation for developing an innovative mathematical formulation of the ERM Index specifically targeted at start-up businesses in SMEs. It allows start-ups to measure risk levels more precisely and manage them more efficiently using the ERM Index. Ultimately, this can help entrepreneurs make informed decisions and decrease failure probability while increasing long-term chances in highly competitive and risky business settings.

One limitation of this study is that the experts selected for developing the risk model were chosen specifically from entrepreneurs in three specific industries. This narrow focus may limit the relevance of findings across different sectors. To enhance the robustness and applicability of the risk model, it is suggested that future studies broaden the range of experts to include entrepreneurs from various industries. In addition, future studies should include participation from policy-makers, shareholders, academics, and investors. Additionally, conducting a survey to gather feedback on the acceptance and practical implementation of the ERM Index in real-world scenarios is recommended. This broader approach would provide a more comprehensive understanding of the risks faced by start-up businesses and ensure that the ERM Index is relevant and useful across different contexts.

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Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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