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Research Article

Risk Assessment for Start-Up Business in SMEs: Qualitative and Mathematical Approach

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Abstract: Due to its crucial role in economic growth and job creation, there has been a notable increase in start-up businesses, particularly small and medium enterprises (SMEs). Many start-up entrepreneurs, however, struggle to sustain their businesses beyond the first five years, and some ultimately fail. This can be attributed to their various risks and challenges during their entrepreneurial journey. Consequently, risk management emerges as a valuable tool for entrepreneurs to identify and effectively address these risks. Hence, this research paper aims to devise a new mathematical formulation for the risk management index of start-up businesses in SMEs, employing qualitative and quantitative approaches. Interviews were conducted with experts to identify the risk factors specific to start-up businesses, and the data collected was subsequently analyzed using the Atlas ti software. Furthermore, a mathematical formulation for the risk management index was developed using a fundamental composite index formulation. The findings reveal the presence of five distinct risk factors in start-up businesses within SMEs. A mathematical formulation and a key indicator index were also established for assessing start-up business readiness in SMEs. These formulations and key indicator indexes are pivotal in enabling entrepreneurs to gauge their readiness for a new business venture. The findings contribute to alternative risk management tools for SMEs, especially for small businesses that are just getting started.

***Keywords*:** risk factors, risk management index, SMEs, qualitative approach, atlas ti, mathematical modelling

MSC: 91B60, 91C99, 91D30

1. Introduction

Being SMEs play a significant role in the global economy [1, 2] accounting for approximately 90% of businesses and over 50% of employment worldwide. They are crucial contributors to GDP and job creation [3]. Over the years, SMEs have increasingly become key players in economic growth. Even during the 1998-1999 Asian Financial Crisis, SMEs demonstrated greater resilience than larger enterprises [4]. These positive contributions of SMEs in Malaysia

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have motivated individuals to engage in small businesses, aspiring to improve their living standards and income levels. Governments worldwide have supported start-ups to stimulate economic growth and employment opportunities [5]. Consequently, the number of start-up businesses has been rising with government backing. However, SMEs face numerous challenges in maintaining long-term viability and remaining competitive in an ever-changing market. As a result, many start-ups encounter difficulties and experience failure [6, 7].

Therefore, effective risk management becomes crucial in addressing unforeseen and unpredictable issues in business, such as political turmoil, economic conditions, natural disasters, and technological advancements [8]. A well-functioning risk management approach aims to control future outcomes rather than reactively responding proactively. By doing so, it can mitigate potential risks while minimizing the impact of potential losses. Enterprise Risk Management (ERM), a distinct aspect of risk management, has been widely used in various industries to identify and manage potential events that may impact a company, providing reasonable assurance of goal achievement. The risk management process involves three fundamental steps: identification, analysis, and evaluation, as outlined in the ISO 31000:2018 risk management guideline [9]. Risk assessment, one of the steps in risk management procedure, which utilizes indicators, has been implemented across multiple industries [10-13].

The use of indices and indicators as a measurement and assessment technique has been widespread in many fields. Using Customer Satisfaction Indices, for example, a nation or company was able to gauge the quality of its output [14]. The performance of the company can also be measured through indices, such as Key Performance Indexes [15] and Construction Performance Indexes [16]. In SMEs, there is enterprise risk management indexes for Shariah-compliant companies as a measurement tool for ERM implementation [17]. However, no study has been conducted on the ERM index for start-up companies in SMEs. Entrepreneurs face many risks, particularly in start-up businesses, which makes it important to have an ERM index in place. In previous index applications, different indicators were given equal weights [18], which led to less accurate results since each indicator has a different significance and weight. Another researcher previously developed the concept of integrated risk perception, management, and response for SMEs and start-ups. This concept uses a web-based platform and cloud database to provide early risk assessments [19], but a literature review is all that is used for the actual risk assessments.

This paper contributes to the literature in several important ways. This paper extends our understanding of risk factors for start-up businesses among SMEs. Previous studies have focused primarily on SMEs and risk factors [20-24]. It is important to gain a broader understanding of risk factors associated with start-up businesses in SMEs by examining the risks they face, which will assist new entrepreneurs in sustaining their businesses, as we know that the first five years of business are the most critical periods for entrepreneurs. Furthermore, we enhanced the study methods because most previous studies used quantitative and statistical analysis. A combination of qualitative analysis and mathematical formulation was used in this study. Finally, as many previous researchers have studied ERM [25-28], this study adds value to an alternative approach to ERM specifically designed for SMEs as well as start-up companies.

As an alternative technique for ERM, this study intends to develop a mathematical formulation of an ERM index and key indicators for start-up businesses in SMEs. In addition, this study aims to identify the risk factors of start-up businesses in SMEs and evaluate their weightage as crucial components of risk assessment and the development of the new risk management index.

2. Literature review

In addition to their strong impact in all economic sectors, SMEs are known for their focus on innovation and their ability to adapt quickly to market changes [29]. As a result, SMEs depend on these characteristics to survive, and if they lack any of these characteristics, they will not be able to survive. The importance of technologies and networking capabilities has also been found to indirectly influence the performance of SMEs in other studies. It is therefore crucial for entrepreneurs in SMEs to invest in new technologies and collaborate with customers, suppliers, and partners [30]. Furthermore, since any business requires financial resources to run, finances can pose a risk to SMEs, particularly the issue of capital funding. According to [31], most start-up SMEs are funded using personal savings, whereas few benefit from bank loans. The lack of market imperfections often causes SMEs to have difficulty securing capital and formal credit, especially in their start-up stages.

Risk management involves the identification, analysis, and proactive response to a range of risk factors inherent in a business's lifecycle. Start-up businesses within SMEs are particularly susceptible to the impact of various risks due to their limited resources and structural characteristics compared to larger companies [32]. Therefore, understanding how to identify, analyse, and respond to different types of risks is crucial for their survival in today's business environment. The techniques and tools used in risk management vary depending on the industry sector and the specific type of business, as each sector, especially within SMEs, has its own objectives and unique business requirements [9].

Various researchers and experts in the field have developed several risk management processes. Examples include the Risk Management for Agricultural Risks, the Risk-Based Thinking Framework, the Operational Risk Management for SMEs, and the Enterprise Risk Management System for SMEs [9]. These risk management processes differ, particularly in the number of steps they employ, allowing for customization based on specific business needs. For instance, there are risk management processes with four steps, five steps, seven steps, and nine steps. However, Hamir and Md Sum [9] argue that risk identification, risk analysis, risk treatment, and risk monitoring and review are sufficient for implementing risk management. These four steps are commonly found in most risk management processes, encompassing the fundamental aspects of risk management [9].

In their research, [8] conducted a systematic literature review using bibliometric tools to investigate risk management in SMEs. Their findings revealed that there are five critical processes involved in risk management for SMEs: risk identification, risk evaluation, risk treatment, monitoring and reporting, and context analysis. Among these processes, previous researchers have primarily focused on studying risk identification and risk evaluation [8]. The International Organization for Standardization's ISO 311000:2018 Risk Management Guideline categorizes risk identification and evaluation as part of the risk assessment steps. [27] developed an Enterprise Risk Management System specifically designed for SMEs. It comprises five key components, with risk identification and risk assessment falling under component two within its multicycle process. However, there is another researchers do not combine risk identification and risk assessment as a single step in the risk management process for construction projects [9].

Risk identification is a crucial stage in which all potential losses and risks affecting a project's progress are identified. [33] emphasise that risk identification involves recognising the possible sources of loss and risks for SMEs. This step should be carried out continuously and systematically. ISO 31000:2018 states that risk identification entails finding, recognising, and describing risks. This step is significant because the risks entrepreneurs or organisations face differ based on their respective sectors or industries. For instance, in the agricultural sector, risks may arise from weather conditions, pests, and climate changes [9]. In the risk-based thinking framework proposed by [34], risk identification includes a detailed description of risks, including their sources, potential events, consequences, and likelihood. The subsequent step is risk analysis, which involves measuring or estimating the potential frequency of losses and the potential impact of a risk on business operations [33]. In the context of small businesses, risk analysis aims to identify risks that significantly impact the business. In contrast, risk evaluation aims to determine the significance of the identified risks for the business. This step involves comparing the risk level obtained from the risk analysis stage [35].

Specific risk management processes incorporate risk identification and analysis into a single component, such as the enterprise risk management system developed by [27]. The researchers suggest that qualitative and quantitative methods can be employed for risk analysis and measurement [27]. Qualitative tools include literature review, interviews, expert judgment, strengths, weaknesses, opportunities, and threats (SWOT) analysis, brainstorming, and the Delphi technique. In contrast, quantitative tools encompass Monte Carlo Simulation, the Risk Matrix approach, Decision Tree Diagrams, and scenario analysis [8]. Risk assessment often involves using key indicators and indices to assess the ranking and level of risk [36]. [37] developed an enterprise risk management index to enhance existing enterprise risk management.

Previous researchers have examined various types of risks. According to [37], start-up businesses are exposed to six key risk factors: market risks, competitive risks, operational risks, people risks, legal and regulatory risks, and financial risks. [38] emphasize the importance of risk management in mitigating potential losses in project quality, schedule, and business operations costs. Additionally, the researchers identified specific risk factors in the context of a healthy kitchen restaurant start-up, including deficiencies in human resources, marketing, and finance [38]. Furthermore, [39] analysed internal and external risks affecting the operations, marketing, finance, and human resources of PT Oesodo Alam Mandiri, a start-up business. [40] discovered five risk factors in entrepreneurial risk: strategic risk, financial risk, environmental risk, market risk, and technological risk. These findings highlight that different sectors or industries face distinct types of risks, necessitating tailored approaches for risk management based on the objectives and nature of each

business.

Composite indexes have been used in many measurement and sustainability model [41-43] due to their role in simplifying complicated information to simple ones using simple mathematical statistics. Composite index is a unique indicator that can integrate two or more independent measurements in order to produce broader, ease-to-use metrics to evaluate management effectiveness so that improvise the overall progress in the management [41]. Besides, according to [42], composite index is a numerical or quantitative measures created from various factors that reflect a country's performance in a given area. Composite indices are mathematical statistics created by combining complicated information into a simple one. [43] used composite index to develop leanness index for SMEs to measure the degree of lean adoption in the organization. Moreover, previous research developed enterprise risk management indexes for Shariah-compliant companies to effectively measure enterprise risk management implementation [17].

3. Methodology

This research aims to create a novel mathematical formulation for the risk management index and key indicators specific to start-up businesses in SMEs. A qualitative approach was utilized to identify and analyse the main risk factors in SMEs. The mathematical approach was then used to create a new risk management index for SMEs.

3.1 *Qualitative approach*

Before developing this mathematical formulation, an in-depth, face to face interview sessions were conducted from Sept 2022 until October 2022, with nine experts from SMEs in the East Coast region of Malaysia. All participants are entrepreneurs from SMEs who have at least five years of relevant experience. A semi-structured questionnaire was used for these interviews, aimed to identify the risk factors associated with start-up businesses in SMEs. Data can be gathered and structured using semi-structured expert interviews while maintaining an openness to including new and unexpected information in the interview. Following the recommendation by [44], the number of interview participants was between six and eight to ensure diverse perspectives were obtained. The sampling size for the study was determined based on the concept of saturation, which occurs when no new information can be obtained from additional data [45]. The interview sessions lasted between 30 to 55 minutes.

Table 1. Seven steps of thematic analysis by Abdul Ghani et al. [46]

Step	Descriptions
1	Uploading verbatim, video, or photograph as the primary document.
2	First-level coding: to identify the main construct or concept across the primary documents.
3	Second level coding: to review code names and re-code constructs or concepts as emerging themes and subthemes.
4	Naming themes and subthemes.
5	Identifying the association between themes and subthemes using the network diagram.
6	Preparing the quotation report and importing the network diagram.
7	Writing-finalizing analysis.

Audio recordings were made during the interviews to avoid falsification and entirely focus on the conversation. Then, transcriptions were made for data analysis. Subsequently, the collected data underwent analysis using Thematic Analysis in the software Atlas ti, developed by [46] and involved seven steps (Table 1). It is worth noting that the approach would have been different if the observation had been conducted in a laboratory setting [47]. In first-level

coding, this study revealed five emerging subthemes and for second-level coding, the study identified emerging categories for all subthemes. These steps facilitated the identification of risk factors specific to start-up businesses in SMEs and served as a guide for developing a questionnaire on the topic.

Additionally, the software enabled the creation of visual aids such as Sankey Diagrams and Code-Document Tables. These visual outputs proved valuable in determining the ranking and weighting of each risk factor for start-up businesses in SMEs.

3.2 *Mathematical approach*

Based on the assigned weights, a comprehensive mathematical formulation for the risk management index of start-up businesses in SMEs was developed, accompanied by establishing key indicators. The study utilizes the foundational mathematical formulation of a composite index, as [48] outlined.

Index number

$$I = \frac{Q_1}{Q_0 \times 100},$$

where,

Q_0 = Quantity at base time;

Q_1 = Quantity at given time.

Composite index

$$I^{-} = \sum (I_i W_i) \Big/ \sum W_n, \tag{1}$$

where,

i = 1, 2, 3, 4, 5;

n = 1, 2, 3, 4, 5;

I = index number;

W = weightage.

In this study we assume that $\sum W_i = W_i$ [49].

Mathematical approach utilized the questionnaires that consists of five risk factors and their weightage found through qualitative approach (interview). The entire process for developing the new mathematical risk management index in this study is summarized in Table 2 below.

Table 2. Five steps for construction of new mathematical formulation risk management index

Step	Descriptions
1	In-depth interview sessions with experts in SMEs for data collection method.
2	Risk identification-seven steps of thematic analysis in atlas ti. developed by Abdul Ghani et al. [46].
3	Weightage development-sankey diagram and code document table in atlas ti.
4	Construction of questionnaire based on five risk factors and their categories.
5	New mathematical formulation of risk management index and key indicator risk index-using weightage and general formulation of composite index by Ghazali et al. [48]

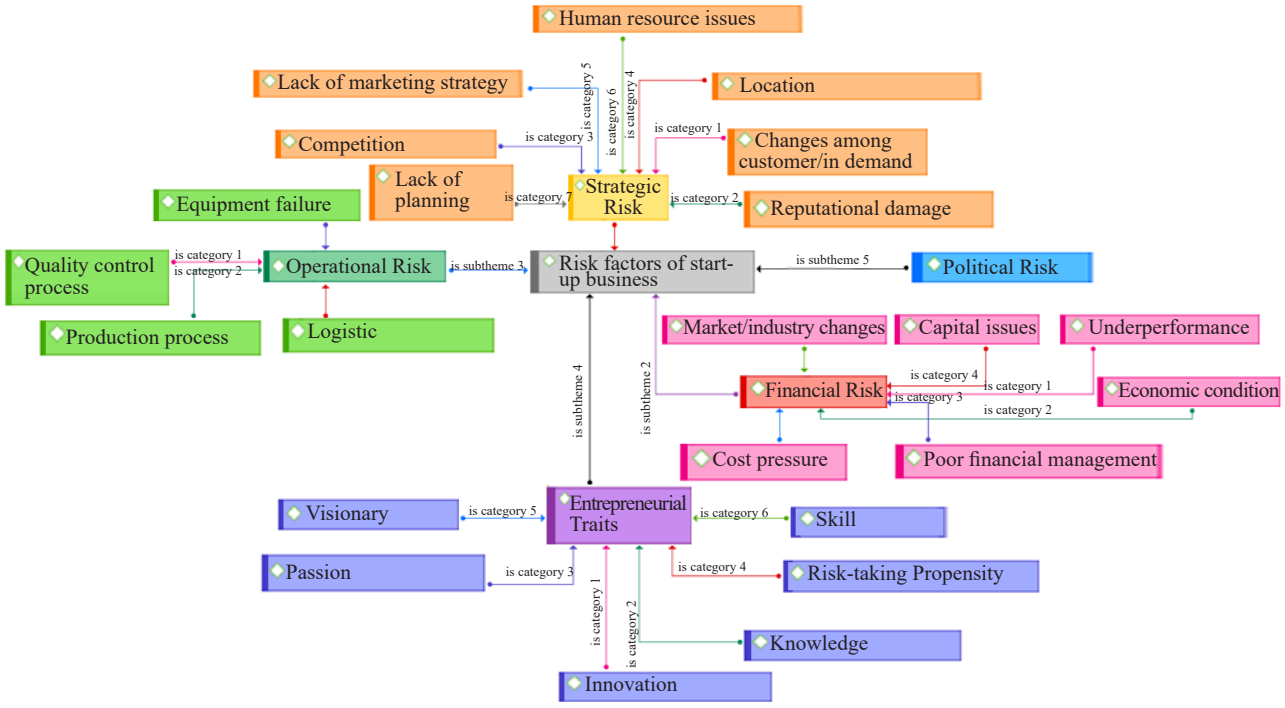
Source: Authors' elaboration

4. Findings and discussion

This results in this study was divided into three sections; 1) Identification of Risk Factors for Start-up Businesses in SMEs; 2) Evaluation of weightage for risk factors of start-up businesses in SMEs; 3) Construction of new mathematical formulation for risk management index of start-up businesses in SMEs; 4) Development of key indicator for risk management index for start-up businesses in SMEs.

4.1 *Identification of risk factors for start-up businesess in SMEs*

Using qualitative analysis, one theme and five subthemes was revealed in this study. The theme for this study is risk factors of start-up businesses in SMEs, while for subthemes are Strategic Risk, Financial Risk, Operational Risk, Political Risk, and Entrepreneurial Traits. In addition, there are several categories under each subtheme. For Strategic Risk, there are seven categories which are lack of planning, competition, lack of marketing strategy, human resource issues, location, changes among customer/in demand, and reputational risk. For Financial Risk, there are six categories; market/industry changes, capital issues, underperformance, economic condition, poor financial management, and cost pressure. Categories under Operational Risk are equipment failure, quality control process, production process, and logistic. There are six categories under Entrepreneurial Traits, which are visionary, passion, innovation, knowledge, risk-taking propensity, and skills. However, there is no categories under Political Risk. Illustration of the risk factors of start-up businesses in SMEs and its categories found in this study shown in Figure 1.



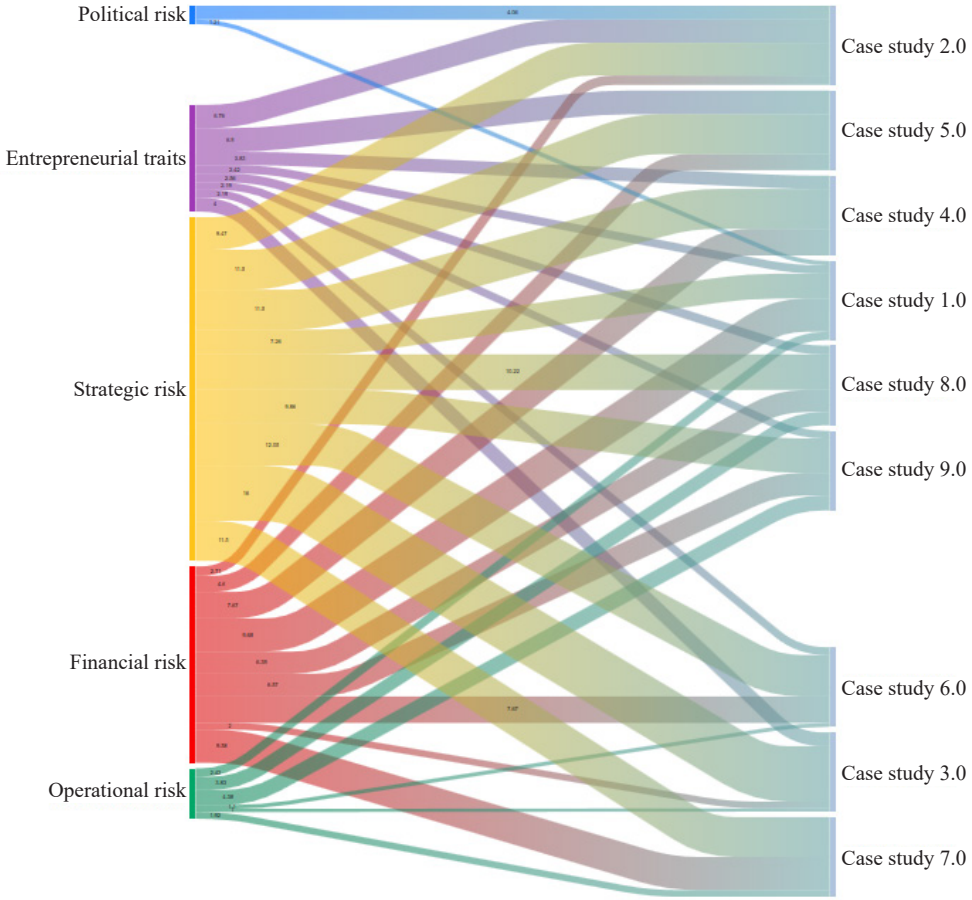
Source: Authors' elaboration (developed using ATLAS.ti)

Figure 1. Risk factors of start-up businesses in SMEs and its categories

4.2 *Evaluation of weightage for risk factors of start-up businesses in SMEs*

Furthermore, qualitative analysis using Atlas ti. also discovered the weightage of each risk factors using Sankey Diagram and Code-Document Table (CDT Table). Figure 2 shows the result of Sankey Diagram, while Figure 3 shows the result of CDT Table obtained from this study. According to Sankey Diagram in Figure 2, it is shows that Strategic

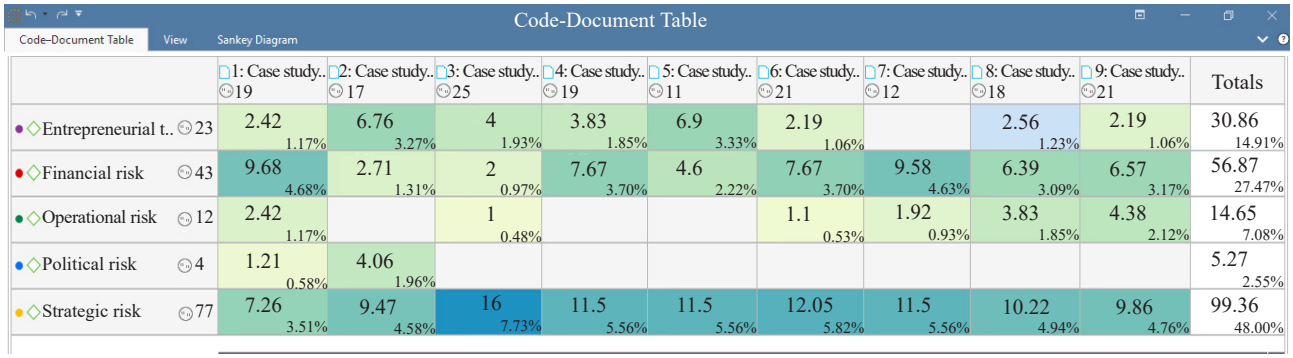
Risk are the most prominent area conquered, indicating that majority of participants had mention about this risk factor. In contrast, the less area is Political Risk, indicates only a few participants point out them. Financial Risk is the second most prominent topic discussed by the participants in this study, followed by Entrepreneurial Traits. The second least area conquered according to Sankey Diagram is Operational Risk.



Source: Authors' elaboration (developed using ATLAS.ti)

Figure 2. Sankey diagram

Next, Code-Document Table (CDT) analysis in Figure 3 found the relative frequency for each risk factors and based on this results, we compute the ranking for each risk factors in start-up businesses in SMEs. Risk factors with the highest relative frequency placed at the first ranking, while risk factors with the lowest relative frequency placed at the last ranking of risk factors for start-up businesses in SMEs. Based on the CDT analysis, risk factors with the highest relative frequency is Strategic Risk with 99.36. Thus, Strategic Risk is placed at the first ranking for risk factors of start-up businesses in SMEs. The second ranking is Financial Risk because this risk factor has the second highest relative frequency with 56.87. Next is Entrepreneurial Traits with relative frequency is 30.86. The second last ranking is Operational Risk with the value of relative frequency is 14.65. Lastly, Political Risk has the lowest relative frequency which is 5.27, thus this study placed it at the last fifth ranking in the risk factors of start-up businesses in SMEs. The summarization of the ranking and total relative frequency for the risk factors of start-up businesses in SMEs according to CDT Analysis is shown in Table 3.



	1: Case study.. 19	2: Case study.. 17	3: Case study.. 25	4: Case study.. 19	5: Case study.. 11	6: Case study.. 21	7: Case study.. 12	8: Case study.. 18	9: Case study.. 21	Totals
Entrepreneurial t.. 23	2.42 1.17%	6.76 3.27%	4 1.93%	3.83 1.85%	6.9 3.33%	2.19 1.06%		2.56 1.23%	2.19 1.06%	30.86 14.91%
Financial risk 43	9.68 4.68%	2.71 1.31%	2 0.97%	7.67 3.70%	4.6 2.22%	7.67 3.70%	9.58 4.63%	6.39 3.09%	6.57 3.17%	56.87 27.47%
Operational risk 12	2.42 1.17%		1 0.48%			1.1 0.53%	1.92 0.93%	3.83 1.85%	4.38 2.12%	14.65 7.08%
Political risk 4	1.21 0.58%	4.06 1.96%								5.27 2.55%
Strategic risk 77	7.26 3.51%	9.47 4.58%	16 7.73%	11.5 5.56%	11.5 5.56%	12.05 5.82%	11.5 5.56%	10.22 4.94%	9.86 4.76%	99.36 48.00%

Source: Authors' elaboration (developed using ATLAS.ti)

Figure 3. Code-document table

Table 3. Ranking and relative frequency for risk factors of start-up businesses in SMEs based on CDT analysis

Ranking	Risk factors of start-up business in SMEs	Relative frequency
1	Strategic risk	99.36
2	Financial risk	56.87
3	Entrepreneurial traits	30.86
4	Operational risk	14.65
5	Political risk	5.27

Source: Authors' elaboration

Based on the result of Sankey Diagram and CDT analysis, the study revealed the most significant risk factor and the least significant risk factor. The risk factor with the highest relative frequencies and first ranking are considered the most significant. In contrast, the risk factor with the lowest number of relative frequencies and at the lowest ranking is considered the least significant. Thus, the study revealed the most significant risk factors of start-up businesses in SMEs is Strategic Risk, while the least significant factors of start-up businesses in SMEs is Political Risk. This finding is in line with previous researchers who studied the strategic risk is one of the critical risks faced by entrepreneurs [40, 49]. Even though this study found that Political Risk is least critical in risk factors of start-up businesses in SMEs, previous researchers still recognized political risk as one of the risk in SMEs [50-52]. Therefore, we cannot ignore this type of risk. We need to manage it to protect our assets and maximize returns carefully. Political risk can create uncertainty and instability that affect economic conditions. This, in turn, can lead to fluctuations in raw materials prices. These price changes can ripple through the global economy, affecting industries, businesses, and consumers and ultimately contributing to economic uncertainty and potential stakeholder challenges [53-55].

Then, this study developed a weightage for each risk factors based on result in Table 2. The weightage of each risk factors is determined based on its ranking in Table 2. For the risk factor placed in the first ranking, the weightage is the highest which is five, while for the risk factor placed in the last ranking, the weightage is the lowest which is one. Therefore, the weightage for Strategic Risk which is placed at the first ranking is five, while the weightage for Political Risk which is placed at the last ranking is one. Thus, the summarization for risk factors and its categories with their ranking and weightage is demonstrate in Table 4.

Table 4. Ranking and weightage for risk factors and its categories

Ranking	Risk factors	Categories of risk factors	Weightage
1	Strategic risk	Changes among customer/in demand Reputational damage Competition Location Lack of marketing strategy Human resource issues Lack of planning	5
2	Financial risk	Underperformance Economic condition Poor financial management Capital issues Cost pressure Market/industry changes	4
3	Entrepreneurial traits	Visionary Passion Innovation Knowledge Risk-taking propensity Skills	3
4	Operational risk	Quality control process Production process Equipment failure Logistic	2
5	Political risk	-	1

Source: Authors' elaboration

4.3 *Construction of new mathematical formulation for risk management index of start-up businesses in SMEs*

Once the risk factors are identified, and their weights are determined, the questionnaire can be designed. The items for the questionnaire was constructed based on the result in Table 4. A 10-point Likert scale (refer Figure 4) will be used to answer the questionnaires. Table 5 shows the questionnaires of risk factors for start-up businesses in SMEs with their weightage and formulation risk index.

(Strongly disagree) 1___ 2____3____4 ___ 5____6____7____8_____9____10 (Strongly agree)

Figure 4. Likert scale

Table 5. Questionnaires of risk factors of start-up businesses in SMEs with weightage and formulation risk index

Risk factors	Statements	Weightage	Formulation risk index
Strategic risk	Our company rarely monitors, evaluates, and manages strategic risks. We are slow to response to customer complaints. Our employees lack work experience and skills. Our ability to track changes in customer needs and wants is bad. Our response to competitive moves in the marketplace is bad. My company face employee turnover. My company fails to promote our products continuously.	5	$\sum_{i=1}^{7} a_i$ $i = 1, 2, 3, 4, 5, 6, 7$
Financial risk	My company lacks a quality debt management plan. My company has poor financial management. I afraid to invest (buy goods) for business purposes. My company often experience losses. My company has capital issues. Cost pressure nowadays effects my business. Our business' sales have declined in the past two years.	4	$\sum_{i=1}^{7} b_i$ $i = 1, 2, 3, 4, 5, 6, 7$
Entrepreneurial traits	Being an entrepreneur is not my passion. I rarely identify the risk of every action taken in connection with the business. I am not competent enough to solve difficult problems. I am not confident to deal efficiently with unexpected events. I cannot see myself as someone who makes plans and follows through with them. I cannot see myself as someone who is original, comes up with new ideas.	3	$\sum_{i=1}^{6} c_i$ $i = 1, 2, 3, 4, 5, 6$
Operational risk	Manufacturing of product always delayed, do not meet with the schedule. My company do not implement quality control process, to check our final product. There is lack of effective production process. Equipment do not service regularly. My company do not have proper management for logistic process.	2	$\sum_{i=1}^{5} d_i$ $i = 1, 2, 3, 4, 5$
Political risk	Political situation effects my business. Political issues effect my business economically.	1	$\sum_{i=1}^{2} e_i$ $i = 1, 2$

Source: Authors' elaboration

Finally, this study developed risk management index of startup business by modifying the basic formulation of composite index in equation 1 and finding from Table 5. From equation 1, W_i and W_n (weightage of the risk factors) can be assessed from Table 4, while I_i (index number for every risk factors) is the sum of the Likert scale ratings determined by entrepreneurs for each item in the questionnaire from Table 5. The detailed formulation of risk index for each risk factors is shown in Table 5.

From the Table 5, the study developed the composite index of the general function of start-up business index for start-up businesses in SMEs as follow.

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

$$= \frac{\left[\begin{array}{l} W_1 \sum (\text{Strategic risk})_i + W_2 \sum (\text{Financial risk})_i \\ + W_3 \sum (\text{Entrepreneurial traits})_i + W_4 \sum (\text{Operational risk})_i + W_5 \sum (\text{Political risk})_i \end{array}\right]}{\left[W_1 + W_2 + W_3 + W_4 + W_5\right]}$$

$$= \frac{\left[\begin{array}{l} 5 \sum (\text{Strategic risk})_i + 4 \sum (\text{Financial risk})_i \\ + 3 \sum (\text{Entrepreneurial traits})_i + 2 \sum (\text{Operational risk})_i + 1 \sum (\text{Political risk})_i \end{array}\right]}{\left[5 + 4 + 3 + 2 + 1\right]}$$

$$= \frac{\left[5 \sum_{i=1}^{7} a_i + 4 \sum_{i=1}^{7} b_i + 3 \sum_{i=1}^{6} c_i + 2 \sum_{i=1}^{5} d_i + 1 \sum_{i=1}^{2} e_i\right]}{15} \tag{2}$$

Where,

a_i is the value of Likert scale answered by entrepreneurs' perspective regarding Strategic Risk faced by them which consists of seven items.

b_i is the value of Likert scale answered by entrepreneurs' perspective regarding Financial Risk faced by them which consists of seven items.

c_i is the value of Likert scale answered by entrepreneurs' perspective regarding Entrepreneurial Traits faced by them which consists of six items.

d_i is the value of Likert scale answered by entrepreneurs' perspective regarding Operational Risk faced by them which consists of five items.

e_i is the value of Likert scale answered by entrepreneurs' perspective regarding Political Risk faced by them which consists of two items.

4.4 *Development of key indicator for risk management index of start-up businesses in SMEs*

There are three layers of key indicator that has been used in risk assessment for measuring the index. The key indicator for risk index of start-up businesses in SMEs will indicate the level of risk either it is high, medium or low level [56]. In order to determine the value for three layer of range which are high, medium and low level, we make an assumption that the respondent will answer the all items in questionnaire with highest Likert scale which is 10 and lowest Likert scale which is one. The calculation is shown as below using the equation 2 above.

$$\text{Maximum range} = \frac{\left[\begin{array}{l} 5(10+10+10+10+10+10+10) + 4(10+10+10+10+10+10+10) \\ + 3(10+10+10+10+10+10) + 2(10+10+10+10+10) + 1(10+10) \end{array}\right]}{15}$$

$$= \frac{\left[5(70)+4(70)+3(60)+2(50)+1(20)\right]}{15}$$

$$= \frac{930}{15}$$

$$= 62$$

$$\text{Minimum range} = \frac{\left[\begin{array}{l}5(1+1+1+1+1+1+1)+4(1+1+1+1+1+1+1)\\+3(1+1+1+1+1+1)+2(1+1+1+1+1)+1(1+1)\end{array}\right]}{15}$$

$$= \frac{\left[5(7)+4(7)+3(6)+2(5)+1(2)\right]}{15}$$

$$= \frac{93}{15}$$

$$= 6.2$$

Range of differences = Maximum range – Minimum range

$$= 62 - 6.2$$

$$= 55.8$$

Range of one layer = Range of differences / 3

$$= 55.8 / 3$$

$$= 18.6$$

Low range minimum = 6.2

Medium range minimum = $6.2 + 18.6 = 24.8$

High range minimum = $62 + 18.6 = 43.4$

Thus, the construction of key indicator for start-up risk index range is shown in Table 6.

Using this mathematical formulation (equation 2) and key indicator, entrepreneurs can measure their risk in their businesses. Having high marks indicates a high degree of risk, while low marks indicates a low degree of risk. This finding can be one of the alternative tool in risk management for SME that can help entrepreneurs to evaluate their level of risk in their business and measure their readiness to start a new business. It is important for entrepreneurs to implement additional risk management steps, like risk mitigation or risk transfer, even though the system has already been implemented [57-61].

Table 6. Key indicator for start-up business risk index

	Range
High	43.4-62.0
Medium	24.8-43.3
Low	6.2-24.7

Source: Authors' elaboration

5. Conclusion and recommendations

A risk assessment, according to ISO 31000:2018, involves identifying, analysing, and evaluating risks. Thus, this research paper aims to create a mathematical framework for evaluating the risk management of start-up businesses, along with a key indicator for assessing this risk. Interviews with SME experts were conducted to identify the risks associated with start-up businesses in SMEs. The weightage for each risk factor was then determined using the Sankey Diagram and Code-Document Table in Atlas ti. software. By combining the weightage of risk factors with a composite index, a novel mathematical formulation for measuring the risk management index of start-up businesses in SMEs was devised. Additionally, a key indicator for the start-up business risk index was developed.

This study identified five key risk factors for start-up businesses in SMEs: Strategic Risk, Financial Risk, Entrepreneurial Traits, Operational Risk, and Political Risk. Among these factors, Strategic Risk was found to be the most significant, while Political Risk was deemed the least significant. Furthermore, each risk factor is classified into several dimensions based on the findings of this study. A framework for identifying risk factors for start-up businesses in SMEs can be developed with these findings, which can serve as a guideline for new entrepreneurs, especially those who are just starting out. As well, it helped researchers design a set of questionnaires that would later be used to assess entrepreneurs' readiness to start businesses.

Furthermore, the study determined the ranking and assigned a weightage to each risk factor. It has been stated previously that not all risks are created equal. Therefore, prioritising risks according to their likelihood and impact is essential. The classification and ranking of risks can enable entrepreneurs to focus on the most significant risks. The weightage also plays a crucial role in the development of the mathematical risk management index for start-up businesses in SMEs. This mathematical framework is essential for assessing the level of risk entrepreneurs face in their business ventures. It also gauges their preparedness to embark on a new business venture. This discovery holds significant value for entrepreneurs in SMEs, particularly those seeking to initiate a new business venture.

This research offers fresh perspectives on risk management and Enterprise Risk Management tailored explicitly for start-up businesses. The findings of this study will prove highly advantageous for small and medium enterprises, especially start-ups, as they can serve as a reference point for evaluating their preparedness to enter the market. By doing so, businesses can effectively evade failure and ensure long-term sustainability. Moreover, entrepreneurs can leverage these identified risk factors to implement robust risk management procedures. Risk factors associated with start-up businesses in SMEs and the new mathematical formulation of ERM can be valuable tools for entrepreneurs, policymakers, and stakeholders.

The findings can be a guideline before starting a new business. In this way, the potential for their business to fail will be decreased. Thus, SMEs, especially in Malaysia, can improve their performance and increase their economic output. In addition, this mathematical formulation can be an effective ERM for innovation and productivity. Policymakers may want to encourage start-ups to adopt this ERM tool to boost economic efficiency and competitiveness. The government may also emphasize well-designed policies to provide start up founders with training, resources, and mentorship to enhance their ERM abilities. These policies can foster an entrepreneurial culture while ensuring start-ups are prepared to manage risks effectively.

It is recommended that future investigations and research employ alternative analyses, such as Fuzzy Delphi, to validate the results of risk factor ranking and weightage. Comparing these findings can yield more profound insights into developing a risk management index system. In addition, future researchers can use quantitative analysis, such

as Structural Equation Modelling (SEM), to better understand the relationship among risk factors found in this study. Furthermore, this study suggests that future researchers explore the acceptance of this new system among entrepreneurs in SMEs.

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Conflict of interest

There is no conflict of interest for this study.

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