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Abstract: Start-ups across all sectors are facing many challenges during the COVID-19 era. This paper aims to assess the significant risks faced by start-ups during the COVID-19 pandemic using a multi-grade fuzzy logic approach. A case study is conducted using multi-grade fuzzy for assessment of manufacturing start-ups' risk. The conceptual model for evaluation of risk is developed with 3 enablers, 10 criteria, and 33 attributes. The multi-grade fuzzy is used for risk assessment and importance performance analysis (IPA) used for classification of risk attributes. The overall risk index for case start-up is 6.47. It pertains to the range (6–7), which is classed as 'risk'. Finally, seven critical attributes are identified using IPA. The proposed assessment framework will help the start-ups managers to reduce the risk level of their operation in COVID-19 era.

Keywords: start-up risk; risk assessment; COVID-19 era; new venture; multi-grade fuzzy; importance performance analysis; IPA.

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1 Introduction

The main drivers of economic growth and job development, start-ups have arisen and are also a catalyst for radical innovation. India has the world's third largest start-up ecosystem; it was predicted to see year-on-year growth 12–15% steady growth (Deccan Herald, 2020); India possesses about 50,000 start-ups; about 8,900–9,300 of these are technology start-ups. Alone, 1,300 new tech start-ups were born in 2019, suggesting that 2–3 technology start-ups are born every day (Economic Times, 2019).

Some companies are booming, while others are struggling (Donthu and Gustafsson, 2020). Start-ups have continued to play a vital role in economies during the COVID-19 crisis. Unexpected emergencies occurred, such as the ongoing COVID-19 pandemic, which has far-reaching consequences for society (Ratten, 2020). Some creative new start-ups have responded rapidly and flexibly to the pandemic and have been crucial in helping many countries transition towards completely digital jobs, education and healthcare, as well as providing medical products and services with innovative solutions (Shen et al., 2020). Most of the current start-ups, however, face major challenges, as they are more exposed to the shocks introduced by COVID-19 than older incumbents. Invention, self-control, and risk-taking all contribute significantly to entrepreneurial personality (Subagyo and Ernestivita, 2020). A start-up company will confront ongoing obstacles in today's global business climate, including issues in controlling business risk (Saputra et al., 2021). Compared to other small and medium-sized enterprises (SMEs), they tend to participate in high-risk operations, facing limitations in obtaining conventional financing, and have a formative relationship with suppliers and consumers at best. Like established organisations, which have a larger risk appetite, start-ups act significantly when it comes to analysing and reacting to competitiveness, and they perform differently when it comes to exercising innovation (Behl, 2020). There are several sorts of risk, such as 'entering the unknown,' 'committing a relatively big share of assets,' and 'borrowing heavily' (Linton, 2019). Understanding the factors of new venture failure and success is a long-standing issue in studies of new business venture and entrepreneurship (Cantamessa et al., 2018). Risk management is an essential feature to consider when evaluating the efficacy of business incubation programme (Wonglimpiyarat, 2018). "What are the major challenges that these organizations could/will face, as they are fragile, vulnerable, and extremely sensitive businesses dealing with the highest degree of uncertainty, particularly during such a pandemic?" remains unanswered (Salamzadeh and Dana, 2020). Therefore, the objective of this paper is to build a conceptual model for assessing the risks faced by start-ups during COVID-19 era. The present study identifies enablers for risks along with the criteria and attributes for each. The assessment framework will allow the start-ups to analyse the risk. This paper provides suggestions to the critical attributes which can be taken by the start-ups to reduce the risk.

2 Literature review

In the growing global business paradigm, start-up enterprises and small companies have become interwoven functionaries of an economy. Most start-ups become aggressive in order to gain market share quickly through disruptive technologies and evaluate market viability. Consumption and investment risk might arise as a result of such a strategy

(Rajagopal and Davila, 2020). Small businesses with limited resources and expertise are compelled to employ proactive methods and pursue market niche possibilities. These high-risk behaviours make gaining a competitive edge difficult (Naeiji and Siadat, 2019). Stephany et al. (2020) proposed a data-mining method to evaluate the unique risks of the industry associated with COVID-19. They discussed a possible source of data that could provide an empirical basis for identifying industry-specific economic risks associated with COVID-19 and modelling the economic impacts of the current crisis. Shen et al. (2020) analysed the ways in which collaborative intelligent manufacturing innovations are used to enhance the flexibility and survival of manufacturing supply chains and businesses at five levels to tackle major disasters: supply chain, business, warehouse, shop floor, and equipment. In order to provide manufacturing companies and supply chains with the opportunity to respond rapidly to unexpected upsetting events such as the COVID-19 pandemic and ensure the durability and viability of the manufacturing industry, these approaches profoundly incorporate evolving ICT. Neumeyer et al. (2020) discussed the greater awareness of entrepreneurship's role in resolving the waste and resource management issues inflicted by COVID-19. It suggests that academics and professionals are required to agree that entrepreneurs are essential agents of alteration that can help transformation to a more capable and integrated economy. To encourage future studies, they have raised obstacles as well as opportunities to fill this void.

Ratten (2020) discussed how cultural, lifestyle, and the COVID-19 crisis has impacted social entrepreneurship. Also, they addressed the recent lack of convergence among crisis management, entrepreneurship, and research on COVID-19. In that paper, the current literature on crisis management and entrepreneurship has been studied, emphasising the need for greater research integration. It has been found that new ways of thinking that integrate social changes made evident by the COVID-19 crisis to be needed. Due to the apparent continuing uncertainty facing the future, new thought processes must be derived from further research and policy. This would promote a more constructive and pragmatic attitude to the integrated and entrepreneurial viewpoint of the COVID-19 crisis management approach. Amankwah-Amoah et al. (2020) discussed how extreme environmental disruptions and 'black swan' events, such as those triggered by the outbreak of the COVID-19 disease and other global crises, can trigger business failures in the aftermath of increased empirical work across the social sciences on business failure. Ratten and Jones (2020) discussed why COVID-19 could be a ground-breaking opportunity for entrepreneurship education research. Clemens et al. (2020) aimed to obtain data on who was involved in this preparatory buying activity and a main psychological factor that could inspire this behaviour. Using the Prolific virtual recruitment process, respondents were contacted, and financial compensation was given for their participation in the research.

Donthu and Gustafsson (2020) addressed that the current outbreak has had significant economic impacts across the globe, and it does not seem that any nation will be unaffected. Not only does this have economic implications, but all of society is also impacted, which has contributed to drastic shifts in how companies behave and how consumers act. In total, it has been found that 13 papers are covering various sectors of industry (e.g., travel, retail, higher education), improvements in customer and company attitudes, ethical concerns, and employee and leadership aspects. Naudé (2020) argued that if the world wishes to use the COVID-19 epidemic as a historic moment to reform capitalism and reverse the deterioration of democratic systems, then it is crucial to avoid the errors made during and after the global financial crisis. This paper suggested five

principles: decentralisation, democratisation, not neglecting demand, (re-) distribution, and cultivating the population of youth. This requires that the short-term business and economic relief packages be complemented and premised on at least five principles by measures that aim longer. Brown and Rocha (2020) discussed the accessibility of sources of funds for start-ups and small and medium-sized companies are impacted by persistent uncertainties induced by crisis events.

Salamzadeh and Dana (2020) discussed the critical obstacles of Iranian start-ups by interviewing 15 excellently start-ups co-founders. The findings were analysed through simple two-step coding in a focus group session to which start-up co-founders, lawmakers, and academics were invited, and results were discussed. Six vital categories of issues to be addressed have been established, including financial, management of human resources, policies and systems for support, marketing, crisis management, and many others. da Camara et al. (2020) discussed the effect of COVID-19 in tech start-up background to understand the way have responded to unpredictability created by COVID-19. They share knowledge gained in an uncertain environment caused by the COVID-19 pandemic to help agile tech start-ups improve their way of working. Zahra (2021) highlighted the changes brought about by COVID-19 and how the reach and styles of foreign entrepreneurial activities could be influenced in years to come. Zhu et al. (2020) provided a structure for identifying product deletion risks in supply chain activities. Tarei et al. (2020) investigated the relationship between different risk management techniques and risk management practices. Neto et al. (2018) examine risk detection, assessment, and treatment, as well as appetite and organisational maturity in relation to enterprise risk management. Mangla et al. (2018) benchmarked the risk assessment using fuzzy approach.

Verma and Gustafsson (2020) proposed results of a bibliometric analysis in the management and business field of COVID-19 literature to recognise existing research area and suggest a way. The findings and recommendations of the research indicate that COVID-19 will be the trigger for a number of long-term and short-term policy changes and requires the theoretical and analytical attention of researchers. The ideas provided will act as a guide to possible study opportunities. de Caro et al. (2020) discussed the international literature techniques to return to regular orthopedic surgery and normal outpatient clinical operations after a significant outbreak or pandemic effectively and healthily. The awareness will help to further restructure outpatient hospitals and clinics and to efficiently and effectively provide our patients with the best possible level of orthopedic care. Giones et al. (2020) illustrated ways entrepreneurs can take action. Various recommendations were provided such as adjusting to business planning practices that are less formal, more frequent and complex, adopting a frugal corporate culture that preserves and optimises capital that relate directly to the goods and services and the venture's long-term vision, and Informal formalisation in order to share emotional support externally and internally. Akpan et al. (2020) assessed the introduction and use of state-of-the-art technology by small and medium-sized enterprises to enhance operations' efficiency and generate competitive advantages. The emergence of the current outbreak of COVID-19 provides an opportunity to revive a new generation of entrepreneurs to drive the next industrial revolution and to build new business models using cutting-edge technology. Kuckertz et al. (2020) discussed rapid response on three challenging research issues connected to micro-level entrepreneurial crisis management and macro-level policy initiatives. Subagyo and Ernestivita (2020) conducted a thorough literature analysis in order to determine the most important entrepreneurial elements that contribute

to the success of MSMEs, as well as the factors that may be used to quantify their performance. Saputra et al. (2021) recognised and examined the risks in the fledging firm i.e., start-up. Mittal and Madan (2020) investigated the factors of e-start-up finance patterns that impact company performance. Wonglimpiyarat (2018) explores the use of 'risk management and auditing' to technological accelerator. Yordanova (2018) introduces the 'innovation project tool', which intends to outline similar traits of innovation initiatives in aspect of project management and the use of risk management tool for better assessing and analysing project risk. Behl (2020) seeks to explore how digital firms' big data analytics skills assist the tech start-ups achieve a competitive edge and improve business performance.

During the COVID-19 era, in order to reduce risk start-ups have to focus on two important operational aspects, viz. reduce time and resources (Valmohammadi and Dadashnejad, 2021; Kumar et al., 2020; Murali and Prabukarthi, 2020; Roy et al., 2021) and respond quickly to customers' requirements (Abdallah and Ayoub, 2020; Saleeshya et al., 2020; Balakrishnan et al., 2020).

Multi-grade fuzzy logic and importance performance analysis (IPA) is used to develop the model, particularly in start-ups by the following research questions (RQ)s:

RQ 1 How to measure the risks in start-ups during the COVID-19 era?

RQ 2 What are the risk attributes that affects the start-ups during COVID-19?

RQ 3 How critical attributes are identified and addressed in the case-manufacturing start-up?

In order to answer the above research question, the risk assessment in start-ups has been conducted. This assessment framework will enable the start-ups to determine the attributes that affects their operation in the COVID-19 pandemic.

3 Research methodology

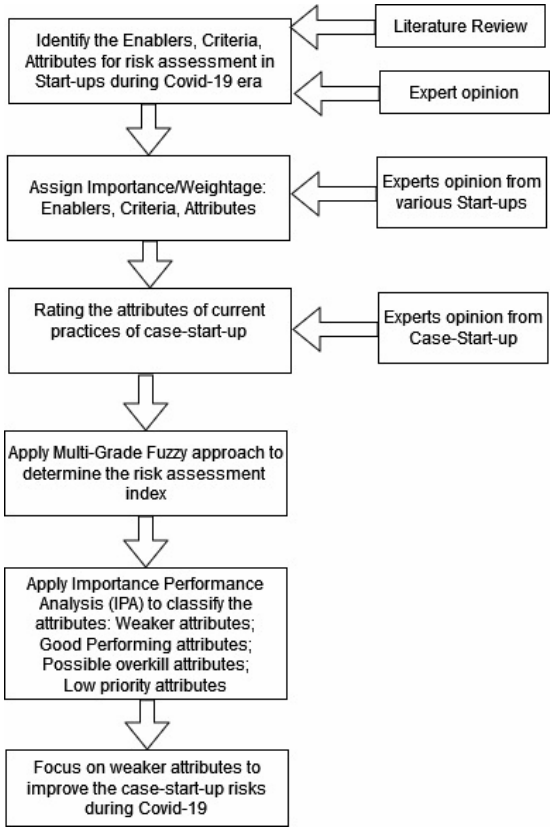
In the current study, the multi-grade fuzzy approach is acquired from Vinodh et al. (2012), Lin et al. (2006), Sridharan and Suresh (2016), Vinodh and Prasanna (2011) and Vinodh and Chintha (2011). The methodology followed during this research begins with the literature review on start-up risk assessment during the COVID-19 era. Then a conceptual model for risk assessment has been developed. Later, a suitable start-up has been identified for conducting the case study. In order to gather data for this study, scheduled interviews with a closed-ended questionnaire were used. The questionnaire was revised and finalised based on the opinions of the experts. The experts are chief executive officers, analysts, and managers of various start-ups in India and their experience ranging from 10 months to 4 years. The details of the experts are given in Table 1. Three enablers were found for risk assessment, followed by 10 criteria and 33 attributes. Finally, the survey was conducted by taking an appointment from these experts for their availability, and each interview took 50 minutes to complete. The first 10 minutes were used to explain the study and the definitions of the enablers, and the rest 40 minutes were used to collect the respondents' responses. Then multi-grade fuzzy logic approach has been applied for the assessment of risk. The risk index has been computed and the practical conclusion was derived. This was followed by the identification of the attributes for improvement. Figure 1 depicts the fuzzy risk assessment recommended

framework of a start-up for decreasing risk during the COVID-19. It is divided into three phases. The first stage is to identify 'enablers,' 'criteria,' and 'attributes' from the literature review. The second phase is selecting a suitable start-up for risk assessment. The final phase is the ongoing evaluation of risk and preparing the start-up to investigate risk sources and reduce them via proper planning.

Table 1 Experts profile

Experts for importance/weightage		
Designation	*Number of respondents*	*Sector*
Chief executive officer	2	Digital marketing, engineering management services
Operations manager	1	Construction
Chief technology officer	1	IT
Business analyst	1	IT
Experts for risk rating		
Chief executive officer	1	Manufacturing
Operations manager	2	Manufacturing
Business analyst	2	Manufacturing

Figure 1 Framework for development of start-up risk assessment during the COVID-19



3.1 Multi-grade fuzzy

Fuzzy logic is based on human logic and makes use of boundary-based conceptual understanding. Probability distribution, linguistic parameters, fuzzy if then, and fuzzy set are all concepts of fuzzy logic (Vinodh and Chintha, 2011). Vinodh et al. (2012) has used multi-grade fuzzy approach for assessment of agility in an Indian electric automotive car manufacturing organisation. Ganesh and Suresh (2016) have used multi grade fuzzy approach for calculation of safety index in case of Indian manufacturing company. Vinodh et al. (2010) have used multi-grade fuzzy approach to measure the agility index. Vimal et al. (2015) have used multi-grade fuzzy approach to evaluate the process sustainability. Vinodh (2011) have used multi-grade fuzzy approach to assess the sustainability of an organisation. Vinodh and Kumar (2012) have used multi-grade fuzzy approach to develop computerised decision support system for leanness assessment. Sridharan and Suresh (2016) have used multi-grade fuzzy approach to assess the environmental sustainability in case of two Indian colleges. Vinodh and Prasanna (2011) have used multi-grade fuzzy approach to evaluate agility in supply chain. Vinodh and Chintha (2011) have used multi-grade fuzzy approach to assess the leanness in manufacturing organisations. Almutairi et al. (2019) have used multi-grade fuzzy approach to assess the leanness of a supply chain in health-care. As witnessed by the vast extant literature for successfully incorporating multi-grade fuzzy approach, this study implements it in the context of risk assessment in start-ups.

This study utilised multi-grade fuzzy to assess the start-ups risk during COVID-19 era. The current study discussed the literature review on risk faced by start-ups during COVID-19. To assess the risk assessment index a new conceptual framework is formed with three enablers, ten criteria and 33 attributes as shown in Table 2.

Table 2 Conceptual model of Start-ups risk during COVID-19 era

Enablers	*Criteria*	*Attributes*
Management risk (H1)	Strategy (H11)	Sudden or prolonged economic downturn will lead to companies considering significant budget cuts that eliminate discretionary spending. (H111)
		Remote work, online education and social distancing will create demand for products and services delivered by the tech industry. (H112)
		The crisis underscores the need for flexible, resilient business models, including increased focus on cash-flow forecasting and impacts on supply-chain and commercial-channel partners. (H113)
		Company valuations may become more attractive for acquisitions by cash-rich companies that have been sitting on the sidelines, while keeping targets in mind. (H114)
	Investment (H12)	Customers not willing to invest big (H121)
		Change in investment patterns (H122)
		Barriers to accessing funding (H123)

Table 2 Conceptual model of Start-ups risk during COVID-19 era (continued)

Enablers	*Criteria*	*Attributes*
Operation risk (H2)	Workforce (H21)	Maintaining the productivity of teams (H211)
		Maintain employee welfare (H212)
		Pressure to reorganise working and collaboration structure (H213)
		Layoff (H214)
		To pay salary to their employees (H215)
		Lack of team management skills (H216)
	Illiquidity (H22)	Reduced sales (H221)
		Low production (H222)
		Cash flow problems (H223)
	Infrastructure (H23)	To define the tools needed to manage the remote work (H231)
		Maintainability of the software development process in the remote environment (H232)
		To provide the necessary infrastructure for all employees (H233)
	Expenses (H24)	Operational cost (H241)
		Maintenance cost (H242)
	Technology (H25)	Availability of new technology (H251)
		Affordability of new technology (H252)
Business environment risk (H3)	Market (H31)	To align expectations with the clients'(H311)
		Facing problem with initial contacts and follow ups (H312)
		Loss of contact with existing customer (H313)
		Meetings with potential customers are simply put back (H314)
		Decline in the demand for goods and services (H315)
		Unable to be compliant to their commitment with their suppliers (H316)
	Global crisis (H32)	Depreciation of the local currency (H321)
		Limited access to international funds and markets (H322)
	Competition (H33)	Uncompetitive pricing from international companies (H331)
		Substitution of domestic goods (H332)

3.2 Case study of a manufacturing start-up

3.2.1 About the case manufacturing start-up

The case manufacturing start-up was established in 2020 and it is located in India with approximately eleven employees. They are producing variety of modern food products. They also supply staple products to the hospitality sectors in India. The risk assessment model was done in this manufacturing start-up. Their quality assurance strategy requires them to work with producers who have met international quality requirements and have certifications from reputable organisations. They are committed to environmental stewardship and the acquisition of environmental friendly materials. They have the capacity to produce 7,000 tons of their products for industrial use. They have been

certified by FSSAI, Halal India, Food Safety & Drug Administration Department of the Government of India, and so on. Five experts from this start-up have participated in the assessment process.

Table 3 Weights and risk rating from experts

Hi	*Hij*	*Hijk*	*R1*	*R2*	*R3*	*R4*	*R5*	*Wijk*	*Wij*	*W*
H1	H11	H111	8	7	6	8	9	0.2761	0.5609	0.3565
		H112	7	9	10	9	6	0.291		
		H113	9	6	8	8	5	0.2611		
		H114	7	8	10	7	5	0.1716		
	H12	H121	7	10	4	4	10	0.3070	0.4390	
		H122	8	9	10	8	8	0.3245		
		H123	6	7	8	8	7	0.3684		
H2	H21	H211	8	9	5	7	5	0.1674	0.2372	0.3178
		H212	8	10	5	4	3	0.1674		
		H213	9	7	8	6	7	0.1866		
		H214	9	8	7	9	7	0.1483		
		H215	6	9	5	2	3	0.1578		
		H216	3	3	7	5	2	0.1722		
	H22	H221	6	8	5	8	1	0.3636	0.2033	
		H222	5	8	5	4	1	0.3223		
		H223	7	7	5	3	6	0.3140		
	H23	H231	6	7	8	5	5	0.3925	0.1299	
		H232	4	6	10	4	7	0.2710		
		H233	6	5	8	7	6	0.3364		
	H24	H241	7	7	6	7	5	0.4897	0.1864	
		H242	9	7	8	6	5	0.5102		
	H25	H251	4	6	5	5	10	0.5125	0.2429	
		H252	3	6	5	6	8	0.4875		
H3	H31	H311	6	7	6	4	3	0.1830	0.3515	0.3255
		H312	5	8	8	9	4	0.1919		
		H313	3	8	7	3	5	0.1741		
		H314	3	9	7	9	1	0.1562		
		H315	6	10	1	6	6	0.1473		
		H316	4	8	10	8	5	0.1473		
	H32	H321	4	8	6	8	8	0.4000	0.3046	
		H322	6	5	5	3	9	0.6000		
	H33	H331	4	3	5	6	5	0.4848	0.3437	
		H332	4	3	6	7	7	0.5151		

3.2.2 Calculations

The start-ups risk assessment index is represented as *H*. It is the product of the overall assessment level of ratings based on each driver (*R*) and the overall weights (*W*) is given by the experts (Chacko and Suresh, 2021; Sreedharshini and Suresh, 2021; Sri and Suresh, 2021). The equation for risk assessment index is

$$H = W \times R \text{ (Anil and Suresh, 2020; Suresh et al., 2020; Menon and Suresh, 2020)}$$

The assessment has been divided into ten grades since the entire risk index involve fuzzy determination. H = {10, 9, 8, 7, 6, 5, 4, 3, 2, 1}. 9–10 represents 'extremely high risk', 8–9 represents 'very high risk, 7–8 represents 'high risk', 6–7 represents 'risk', 5–6 represents 'moderate risk', 4–5 represents 'low risk', 3–4 represents 'very low risk', 2–3 represents 'Very very low risk', 1–2 represents 'no risk', and less than 1 represents 'risk free operations.' To collect data, we used questionnaire with a ten-point Likert scale represents extremely high risk (10 point) to risk free operations (one-point). The weightage has been collected from five experts from different start-ups through semi structured interview. The risk ratings are collected from case manufacturing start-up experts and is captured in Table 3.

3.2.2.1 Primary assessment calculation

The primary calculation is done for the 'strategy (H11)' is given below.

Weights concerning to 'strategy' criterion is W_{11} = [0.2761, 0.291, 0.2611, 0.1716].

Assessment for the practice of 'strategy' criterion is given below as.

$$R_{11} = \begin{bmatrix} 8 & 7 & 6 & 8 & 9 \\ 7 & 9 & 10 & 9 & 6 \\ 9 & 6 & 8 & 8 & 5 \\ 7 & 8 & 10 & 7 & 5 \end{bmatrix}$$

Index concerning of 'strategy' criterion is given by

$$H_{11} = W_{11} \times R_{11}$$

$$H_{11} = [7.79,\ 7.49,\ 8.37,\ 8.11,\ 6.39]$$

Utilising the above principle, the index concerning for the following criteria in risk assessment are obtained and given below.

$$H_{12} = [6.95,\ 8.57,\ 7.42,\ 6.77,\ 8.25]$$

3.2.2.2 Secondary assessment calculation

The calculation concerning to enabler of 'management risk (H1)' is given below as.

Weights concerning to 'management risk' enabler given as H_1 = [0.56, 0.44].

Assessment of 'management risk' enabler is given as below.

$$H_1 = \begin{bmatrix} 7.79 & 7.49 & 8.37 & 8.11 & 6.39 \\ 6.95 & 8.57 & 7.42 & 6.77 & 8.25 \end{bmatrix}$$

Index concerning of 'management risk' enabler is given by

$$H_1 = W_1 \times R_1$$

$$H_1 = [7.428,\ 7.965,\ 7.955,\ 7.527,\ 7.207]$$

Utilising the above principle, the index concerning for the following enabler in risk assessment are obtained and given below.

$$H_2 = [5.975,\ 6.919,\ 6.122,\ 5.589,\ 5.479]$$

$$H_3 = [4.549,\ 5.826,\ 5.849,\ 6.03,\ 6.086]$$

3.2.2.3 Tertiary assessment calculation

The risk assessment value of case start-up has been calculated as follows

$$\text{Complete weight } W = [0.356,\ 0.317,\ 0.325]$$

$$\text{Complete assessment vector } R = \begin{bmatrix} 7.428 & 7.965 & 7.955 & 7.527 & 7.20 \\ 5.975 & 6.919 & 6.122 & 5.589 & 5.479 \\ 4.549 & 5.826 & 5.849 & 6.03 & 6.086 \end{bmatrix}$$

$$\text{Risk index } H = W \times R$$

$$H = [6.029,\ 6.936,\ 6.687,\ 6.424,\ 6.293]$$

The final risk index is the average of $H = 6.47 \in (6 \text{ to } 7)$. $\therefore$ 'risk'.

3.3 Importance performance analysis

IPA is widely used in manufacturing and service industries for classifying the attributes based on the importance and performance (Tzeng and Chang, 2011; Chacko et al., 2021; Vaishnavi and Suresh, 2021; Sreedharshini et al., 2021). In IPA the *x*-axis is the risk rating of the attributes and the *y*-axis is the importance. The mean of the *x*-axis is a 6.3 and the mean of *y*-axis is a 6.99 as a perpendicular line in given in Figure 2.

Quadrant I (Keep up the good work): The attributes in the quadrant are need to maintained as the same and the attributes are 'Lack of team management skills, reduced sales, low production, cash flow problems, to define the tools needed to manage the remote work, availability of new technology, affordability of new technology, to align expectations with the clients and loss of contact with existing customer'.

Quadrant II (concentrate here): The attributes in the quadrant are needed to pay attention by the start-ups managers to reduce risk level of their operations. The attribute is 'Sudden or prolonged economic downturn that will lead companies to consider significant budget cuts that eliminate discretionary spending, remote work, online education and social distancing will create demand for products and services delivered by the tech industry, change in investment patterns, barriers to accessing funding, pressure to reorganise working and collaboration structure and to provide the necessary infrastructure for all employees facing problem with initial contacts and follow ups'.

Quadrant III (possible overkill): The attributes in this quadrant are low importance but high-risk rating. The risk of these attributes should be minimised. The

attributes are 'The crisis underscores the need for flexible, resilient business models, including increased focus on cash-flow forecasting and impacts on supply-chain and commercial-channel partners, company valuations may become more attractive for acquisitions by cash-rich companies that have been sitting on the side-lines, while keeping targets in mind, customers not willing to invest big, maintaining the productivity of teams, layoff, operational cost, maintenance cost, unable to be compliant to their commitment with their suppliers, depreciation of the local currency'.

Figure 2 IPA analysis for risk assessment of start-ups during COVID-19 era

Importance ↑																		
8.8	**Quadrant I**						H221									**Quadrant II**		
8.6											H312							
8.4									H231			H123						
8.2						H311		H251										
8																		
7.8				H222		H313	H252						H213			H112		
7.6							H223											
7.4														H111			H122	
7.2		H216								H233								
7								H212, H314			H211	H113, H121						
6.8						H332												
6.6					H215			H315				H316						
6.4				H331														
6.2															H214			
6							H322											
5.8									H232									
5.6																		
5.4																		
5.2																		
5												H242						
4.8										H241								
4.6													H114					
4.4																		
4.2																		
4	**Quadrant IV**										H321				**Quadrant III**			
	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	
	Risk rating →																	

Quadrant IV (low priority): The attributes in this quadrant are low importance and low risk rating. The attributes are 'maintain employee welfare, to pay salary to their employees, maintainability of the software development process in the remote environment, meetings with potential customers are simply put back, decline in the demand for goods and services, limited access to international funds and markets, uncompetitive pricing from international companies, substitution of domestic goods'.

4 Results and discussion

The case analysis brings two essential findings. First, the final risk index is calculated at 6.47. This belongs to the range (6–7) which is specified as 'risk'. Second, the study has identified seven attributes which are critical and require a special attention by the start-ups. These attributes include, change in investment patterns, barriers to accessing funding, pressure to reorganise working and collaboration structure, to provide the necessary infrastructure for all employees, and facing problem with initial contacts and

follow ups. The risk assessment model helps the manager to investigate and supervise periodically the risk faced by manufacturing start-ups during the COVID-19 pandemic.

The present case analysis used IPA to identify the critical attributes which stands as a barrier to the success of the organisation. The start-ups should focus on these critical attributes to enhance the improvement for smooth working of the organisation and maintain the strong attributes the same. The suggestions for the improvement of critical attributes are given on Table 4.

Table 4 Suggestions for critical attributes

Critical attributes	*Suggestions for improvement*
Sudden or prolonged economic downturn will lead to companies considering significant budget cuts that eliminate discretionary spending.	• Re-assess the cost structure. • Prepare for an economic downturn by appraising which organisational levers to wrench.
Remote work, online education and social distancing will create demand for products and services delivered by the tech industry.	• Support enterprise risk management efforts. • Start upgrading the business plan to consider changes in the marketplace.
Change in investment patterns	• Evaluate current portfolio risk factors. • Create a feasible investment strategy.
Barriers to accessing funding	• Maintain liquidity through cash management. • Approach financial counsellors for guiding and helping in researching on finance options available.
Pressure to reorganise working and collaboration structure	• Rely more on video conferencing and computer-based team tools. • Decide upon which important functions should remain onsite and which can be remote.
To provide the necessary infrastructure for all employees	• Increase ventilation at workplace and ensure strengthening regular hand hygiene as well as personal protection equipment for staffs. • Provide sufficient space for every worker of at least 11 square meters.
Facing problem with initial contacts and follow ups	• Shift to online to stay connected with the customers. • Refocus on the engagement strategies.

The study suggests that the case-start-up should re-assess the cost structure and appraise which organisational levers to wrench. This will help the start-up to face sudden or prolonged economic downturn which will lead to significant budget cut. In addition, the start-ups should support enterprise risk management efforts and should start upgrading the business plan to consider changes in the marketplace. Apart from this, to reduce the risk of change in investment pattern and barriers to accessing funds, the start-ups should evaluate the current portfolio risk factors, should create a feasible investment strategy, maintain liquidity through cash management, and should approach financial counsellors for guiding and helping in researching on finance options available. The case start-up should increase ventilation at workplace and ensure strengthening regular hand hygiene as well as personal protection equipment for staffs. They should also provide sufficient space for every worker of at least 11 square meters. The suggestive measures

recommended to the start-ups are presented in Table 4. The implementation of the above suggestions will help the start-ups to reduce the risk and become successful in this uncertain environment.

5 Managerial/practical implication

The current study identifies the 'enablers,' 'criteria,' and 'attributes' for risk assessment in start-ups during the COVID-19. The assessment model was discussed with the top executives of the start-ups and the approval was obtained. Next, it was circulated to the managers, business analyst, and top executives for weightage and rating. Lastly, the model was developed and weaker attributes were identified so that the start-ups can look into these factors and can take up necessary actions. This study provides three important implications to the management. First, it helps the start-ups to evaluate the risk during COVID-19 era. The specific risk management assessment framework was developed for start-ups using a multi-grade fuzzy approach. Most of the risk characteristics relevant to typical start-ups are captured in this framework. Second, it identifies the attributes which is riskier for start-ups during this pandemic. Third, to fix those critical attributes, it offers suggestive steps. The current IPA has classified seven critical attributes. In order to develop new flexible feasibility plans, a team of experts were formed by the management team to focus on the critical attributes. Experts' recommendations for enhancement will help start-ups focus on the critical attributes and reduce the risk. The risk assessment approach suggested in this study allows practicing managers and executives to evaluate the risk level of their start-ups in a systematic manner. Aside from calculating the risk index, the method allows managers to systematically define dragging factors, which are the barriers to start-up operations. First, top management must be shown the programme in order to get exposure to measure the risk. Then, in order to implement risk evaluation in the organisation, management consent must be received. The operation must be stopped if management approval is not obtained. The team members would then participate in an awareness programme. The team members must be given the data sheet in order to obtain their scores and weights. Following that, the risk index must be calculated using a multi-grade fuzzy approach. Following that, areas for improvement are identified.

6 Conclusions

Compared to other SMEs, start-ups prefer to participate in high-risk operations, face limitations on access to conventional financing, and, at best, have a positive relationship with suppliers and consumers. Many existing start-ups face significant risks, as they are more vulnerable to the disruptions introduced by COVID-19. Risk assessment is becoming increasingly important. Therefore, measuring the current scenario of risk would help and enhance the start-ups to initiate steps to sustain in the unpredictable environment. In this perspective, this paper presents a case study in which the risk of a manufacturing start-up was evaluated using the model that was developed. Three enablers were found for risk assessment, followed by 10 criteria and 33 attributes. The results of the assessment revealed that the start-up is in risk. The final risk index is calculated at 6.47. This belongs to the range (6–7) which is specified as 'risk'. Improvement areas

have been established in order to continue to reduce the risks of start-ups. The study highlighted seven essential traits that companies must pay special attention. Changes in investment patterns, impediments to getting funds, pressure to rearrange working and cooperation structures, offer the required infrastructure for all workers, and dealing with problems with first contacts and follow-ups are all instances of these attributes. The risk assessment approach assists the management in investigating and monitoring the risk faced by manufacturing start-ups during the COVID-19 epidemic on a regular basis. The study recommends the start-up support enterprise risk management efforts and start upgrading the business plan to consider changes in the marketplace. Start-ups can improve workplace ventilation and ensure reinforcement of daily hand hygiene and personal safety equipment for employees. The risks of a start-up could be minimised by improving the defined weak areas, allowing the start-up to sustain.

6.1 Limitation and future research direction

To understand the risk level of the start-ups, the established framework can be used. The case study was conducted in a single manufacturing start-up, and risk was assessed using a multi-grade fuzzy methodology. More case studies for various sectors such as IT, services, digital marketing, construction etc. may be conducted in the future, enhancing the model's realistic validity. It may also utilise correlation to prioritise the risk attributes. Furthermore, the risk framework's evaluation may be experimentally evaluated by attaching it to a quantitative survey following the implementations.

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