Entrepreneurial Business and Economics Review

2022, Vol. 10, No. 2

10.15678/EBER.2022.100206

Modelling the interactions among enablers of technology entrepreneurship: An ISM and Fuzzy-MICMAC approach

Shilpa Sindhu, Rahul S Mor

ABSTRACT

Objective: The objective of the article is to explore the enablers for technology entrepreneurship and model them into a contextual relationship through a qualitative approach. Moreover, the article presents a guiding framework for adopting technology startup by budding entrepreneurs through modelling the enablers.

Research Design & Methods: Factor analysis was applied to identify the significant factors, and Interpretive Structural Modelling (ISM) and Fuzzy-Matriced' Impacts Croises-Multiplication Applique' and Classment (MICMAC) were used to model the factors.

Findings: It was found that 'supportive government policies,' 'more funding options,' and 'intellectual property benefits' are the three significant driving factors. These factors impact 'personal interest' of entrepreneurs through linkage factors and 'attraction for financers' as enablers for adopting technology startup by entrepreneurs.

Implications & Recommendations: This research highlights government and policy initiatives' established role in harnessing innovation and technology growth in any ecosystem. It further propagates that the individual attitude of an entrepreneur towards accepting new ideas for startup based on technology makes a huge difference to the industry. The role of quality investors in promoting technology startup is highlighted.

Contribution & Value Added: This research suggests the roadmap for market players and policymakers to shape the policies and resources so that the budding entrepreneurs get sufficient support and motivation to pursue technology-based startup. The study is unique because it adopts ISM and fuzzy-MICMAC for modelling the factors into a meaningful contextual framework.

Article type:	research article
Keywords:	technology entrepreneurs; enablers; factor analysis; Interpretive Structural Modelling (ISM); Fuzzy-MICMAC
JEL codes:	L11, L26, M13

Received: 2 August 2021 Revised: 24 January 2022 Accepted: 7 February 2022

Suggested citation:
Sindhu, S., & Mor, R.S. (2022). Modelling the interactions among enablers of technology entrepreneurship: An ISM and Fuzzy-MICMAC approach. *Entrepreneurial Business and Economics Review,* 10(2), 97-111. https://doi.org/10.15678/EBER.2022.100206

INTRODUCTION

Entrepreneurs are the source hub of innovation for any economy, and while working towards their goals, they contribute to the nation's economic and social upliftment (Aljuwaiber, 2020). Within the field of entrepreneurship, an emerging field of technology entrepreneurship is making its mark. Technology entrepreneurship consists of two significant areas: technological innovation and entrepreneurship (Mollaei & Gelard, 2016; Sanjaya *et al*., 2015). Technology entrepreneurship is defined as setting up a new business by exploiting technological innovations (Willie *et al.*, 2011). This field reflects entrepreneurs' adaptive and innovative characteristics. Technology entrepreneurs utilize their technical knowledge to come up with naïve concept-based startup to exploit opportunities. Entrepreneurial initiatives concerning new technology contribute in a real sense towards achieving

substantive growth and renovation for any economy (Bailetti, 2012; Nazarov *et al.,* 2017). Technology entrepreneurs act as tangible assets for profit generation, employment creation, and innovation centers (Giacon, 2008). The technology ecosystem is developing gradually in India. At the same time, there is a paucity of research on the entrepreneurial ecosystem for emerging economies like India, which is much needed (Kumar & Das, 2019). People realize that a supportive ecosystem involving different agents, i.e., consumers, supply chains, government, and investors, is required for successful technological entrepreneurship (Baier *et al*., 2021). The ecology, system dynamics, and various internal and external factors impacting technology entrepreneurs are worth exploring to deeply understand the concept of technology entrepreneurship.

Therefore, the objective of the article is to explore the enablers for technology entrepreneurship and provide an insight into the internal and external forces shaping individuals into technology-based entrepreneurial activity. The article has two-fold objectives, *i.e.,* to identify the factors which enable the adoption of technology-based startup by entrepreneurs and to suggest a guiding framework for adopting technology startup based on the contextual relationships among the identified factors through ISM and fuzzy-MICAMC.

From the perspective of this study, the entrepreneurs who focus on adopting technology as a core in their startup (rather than just facilitators) are considered technology entrepreneurs. Several factors identified in the literature act as enablers for the entrepreneurs to pursue the technology-based startup. The relevant factors were identified from the literature and industry participants and verified by domain experts for their relevancy. The selected factors were modelled through interpretive structural modelling (ISM) and Fuzzy MICMAC techniques based on industry feedback and expert opinion. This research suggests a rational framework for policymakers and industry participants to promote technology startup in emerging economies and fetch its uniqueness in employing ISM and fuzzy-MICMAC for modelling the enabling factors for technology startup. Section 2 will present literature review, and section 3 will discuss the research methodology; section 4 will present results and provide a discussion, and section 5 will provide the conclusions.

LITERATURE REVIEW

The impact of entrepreneurial activities on any nation's economy differs across countries (Villegas-Mateos, 2020); the impact may depend on whether entrepreneurship is necessity-based or opportunity-based. Researchers have considered technology entrepreneurship in various ways, *i.e.*, an individual or group initiative towards the application of technology for managing a business (Allahyary & Meigounpoory, 2013); capturing the value of the business (Bailetti, 2012), or considering it just another way of being an entrepreneur (Giacon, 2008), or a solution in search of problems (Bailetti, 2012), and many more. Technology entrepreneurs's opportunity-seeking can lead to business sustainability (Asim *et al.,*2019). Technology entrepreneurship by observing consumer behaviour can foster sustainable product innovations (Bhardwaj, 2020). It can promote new products and markets to revamp the regional economy (Sung *et al.,*2015). Jafari *et al.*(2021) studied relationships (technology readiness factors and digital technology exploration factors) between digital transformation and entrepreneurship towards developing an ecosystem supporting the technological market expansion and technology-driven entrepreneurship. Giones and Alexander (2017) studied and highlighted digital technology entrepreneurship and technology entrepreneurship concepts. Yami *et al.* (2021) advocates that integrating social and human capital in academic technology centres supports innovation and technology entrepreneurship. Innovation is considered the central point for a technology startup. Glukhikh and Golovina (2021) identified four strategies for serial entrepreneurs to set up a technology business and advocated that mass strategies to promote technology entrepreneurs do not work well. As per Badzińska (2016), technology entrepreneurship is primarily impacted by an organisation's internal factors and the business ecosystem. Venkataraman (2004) advocates that tangible factors like govt influence technology entrepreneurship. Support, financial support, infrastructure, etc., and *intangible forces* like access to markets, role models, novel ideas, etc. Similarly, Maysami *et al.* (2019) studied the framework for technology entrepreneurship and proposed 12 dimensions and six criteria.

Literature highlights various factors as motivators or enablers for technology entrepreneurship. As per Allahyary and Meigounpoory (2013), technological features provide differentiation opportunities for an entrepreneur. This provides a competitive edge (Pathak *et al.*, 2013) as technology is required to sustain in today's market scenario (Chalmers *et al.*, 2020; Nazarov *et al.*, 2017). It further helps in fetching Intellectual property rights (IPRs) benefits, matching the customer demand, competing with competitors or fetching more market opportunities and keeping the business updated (Nazarov *et al.*, 2017). The motivation for starting a technology business comes with familiarity and good knowledge about the technologies (Giacon, 2008; Shane & Venkataraman, 2003), or from entrepreneur's prior experience in the domain (Nazarov *et al.*, 2017; Roberts, 1991). The personal interest of the entrepreneur in technology (Allahyary & Meigounpoory, 2013; Chatterjee et al., 2020) or their matching educational qualification (Giacon, 2008; Karyaningsih *et al.*, 2020; Nazarov *et al.*, 2017) can also be one of the motives. Sometimes, an entrepreneur adopts a technology startup, either because of family demands or the expansion of the family business (Roberts, 1991). Availability of funding options for a technology-based startup (Allahyary & Meigounpoory, 2013), support from government policies (Kamarudin & Sajilan, 2013; Kennett & Sun,2021), and financers' interest (Allahyary & Meigounpoory, 2013) also motivate entrepreneurs to pursue a technology-based startup. As per Nacu and Avasilcăi (2014), an entrepreneur's personal and professional traits and environmental factors impact technology entrepreneurship decisions.

Petti and Zhang (2011) state that technology entrepreneurship depends on internal and external factors and institutional factors like intellectual property right (IPR), government policies, social norms, and environmental factors.

The literature highlights the factors responsible for the growth of technology entrepreneurship and the challenges perceived by the stakeholders in different ways. However, a holistic study focusing on the contextual relationship between the responsible factors suggesting a meaningful framework for promoting technology entrepreneurship is missing. This research is an effort towards synergising the factors mentioned in the literature in a meaningful contextual mapping framework.

RESEARCH METHODOLOGY

This study explored the factors that motivate entrepreneurs for a technology startup in India and then modeled them through ISM and fuzzy-MICMAC approaches. The detailed methodology adopted for the same is discussed further:

1. **Identification of significant variables:** Literature was screened, and initially, a total of 21 variables were identified from the literature review (Table 1).
2. **Variable grouping into relevant factors:** Further, to identify the relevancy of variables in this research, primary data was collected from entrepreneurs/potential entrepreneurs in India through a structured questionnaire. The contact details of entrepreneurs were extracted from various internet sources. Both online and offline surveys were floated to a list of 96 entrepreneurs during July 2020. An appropriate response was received from 58 respondents, including different Indian cities, including Delhi, Sonipat, Pune, Surat, Baddi, Dehradun, Chennai, Bangalore, etc. The descriptive statistics of the respondents, including their age, years of experience, education levels, are depicted in Table 2. The respondent's profiling was done, and it was observed that respondents belonged to different designations either in their startup or their company. The responses reflected that only two respondent entrepreneurs out of 58 respondents use technology as a core of their business, which may be called a technology startup in the real sense, while others use technology as an enabler for their food startup. However, when asked about interest in starting a pure technology startup, mixed responses were received. The responses collected were analyzed statistically through SPSS software. The descriptive statistical analysis was done to identify the awareness level and extent of adoption of technology-based entrepreneurial activity. Factor Analysis was carried out to define the responsible factors towards technology-based entrepreneurial inclination among individuals. The KMO and Bartlett's

test values came as significant. Principal component analysis with varimax rotation was used to extract the factors. Accordingly, the rotated component matrix is shown in Table 1. A total of 20 variables (one insignificant variable) with factor loading higher than 0.5 were grouped into six major factors. Six factors explaining a total 73.705% variance are labelled and discussed in Table 3. Factor analysis was used to reduce and group the variables into significant factors, and accordingly, six significant factors were derived (Table 3).

3. **Factor Validation and Modelling**: Further, a focus group discussion was conducted with the domain experts to validate the identified factors. The discussion was organized at one of the author's workplaces in Delhi (India) via online mode on September 21, 2020. A total of five experts were invited to contribute to the discussion. Out of these five experts, three were entrepreneurs in the food sector, and the rest were from academia and research affiliated. The experts were chosen through a professional acquaintance and LinkedIn search. The experts were made aware of the need of the study and the identified factors were shared with them. The experts suggested four more factors in addition to the six factors identified by factor analysis and suggested dropping one factor, viz. family expectations. Therefore, a total of nine factors were identified (Table 4) based on this three-step approach, which was modelled through the interpretive structural modelling (ISM) approach (Agrawal *et al.*, 2017; Chaudhary & Sindhu, 2015; Hassannezhad *et al.*, 2020; He & Pan, 2019).

Table 1. Rotated component matrix

Significant variables	Component					
	1	2	3	4	5	6
To get differentiation opportunity	-0.002	0.605	0.099	0.314	0.062	0.351
Familiarity with the latest technology	0.181	0.128	0.350	0.728	0.090	-0.047
Good knowledge about technology	0.401	0.084	0.078	0.782	0.228	0.134
Wants to expand my family business	0.292	-0.045	-0.023	0.185	0.752	-0.255
I have prior experience	0.485	0.170	0.120	0.335	0.261	-0.488
Avail of adequate external resource for establish techno venture	0.599	0.121	0.101	0.430	0.219	-0.036
Funding Option	0.826	0.120	0.026	0.143	0.061	0.190
To get benefits from IPR	0.716	0.135	0.164	0.033	0.459	0.175
Technology startup get competitive advantage over other	0.735	0.278	0.134	0.115	0.155	-0.145
Seems more profitable	0.657	0.347	0.375	0.085	-0.230	0.054
To match customer demand	0.101	0.829	-0.012	0.176	0.032	-0.055
To compete with competitors	0.314	0.772	0.210	-0.242	0.039	0.114
More market opportunity at national and international level	0.164	0.870	0.084	-0.048	-0.013	-0.250
My family demands so	0.080	0.010	0.164	0.105	0.808	0.225
Supportive government policies	-0.053	-0.127	0.392	0.392	0.439	0.315
This is require to sustain in today's market scenario	0.269	0.688	0.078	0.190	-0.115	0.292
My education matches with technology	-0.115	0.088	0.642	0.362	0.200	-0.047
Personal interest	0.168	0.119	0.075	0.077	0.095	0.842
To keep the business updated	0.170	0.192	0.737	0.448	-0.148	0.099
To attract financers	0.291	0.075	0.812	-0.006	0.070	0.126
To gain advantage from government schemes	0.290	0.098	0.663	-0.022	0.490	-0.136

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 10 iterations.
Source: own study.

Table 2. Descriptive demographic characteristics

Categories / Description		No. of Responses	Percentage
Age	>40	1	1.7
	20-30	55	94.8
	30-40	2	3.4
Education Level	12th	1	1.7
	Graduation	37	63.8
	Post-graduation other than MBA	8	13.8
	MBA	12	20.7
Professional status	Entrepreneur	33	56.8
	Managing family business	18	31.03
	Potential Entrepreneur	7	12.06
Scale of the Organization	Large scale	16	27.6
	Medium scale	16	27.6
	Small scale	26	44.8
Usage of latest technologies in the Company	Yes	32	55.2
	No	13	22.4
	Not sure	13	22.4
Number of respondents interested in starting a purely Technology-based startup	Yes	16	27.6
	Maybe	24	41.4
	No	16	27.6
	Already started	2	3.4

Source: own study.

Table 3. Factors identified through factor analysis

Sr. No.	Factors	Description
E1	More Funding Options	Entrepreneurs feel that there are much broader funding options available for Technology startup (Kamarudin & Sajilan, 2013; Nazarov *et al.*, 2017). External resources also exist for establishing a technology venture (Nazarov *et al.*, 2017).
E2	Better Market Opportunities	Entrepreneurs feel technology can help them gain differentiation opportunities (Allahyary & Meigounpoory, 2013). It has also been perceived that technology entrepreneurship can be a workable solution to sustain in ever-changing and highly competitive market structures (Nazarov *et al.*, 2017).
E3	Supportive government schemes	As technology entrepreneurship is an emerging field, various government schemes keep coming up in this area, and entrepreneurs want to gain an advantage from these upcoming govt. schemes (Kamarudin & Sajilan,2013; Nazarov *et al.*, 2017).
E4	Knowledge of Technology	Familiarity with the latest technologies makes entrepreneurs realize great potential and reason to initiate a technology-based startup (Giacon, 2008; Shane & Venkataraman, 2003).
E5	Family Expectations	Sometimes family culture and family members' demand make the entrepreneurs pursue technology entrepreneurship options or a desire to expand their family business (Giacon, 2008; Roberts, 1991).
E6	Personal Interest	The personal interest of the entrepreneurs towards technology entrepreneurship is also one of the major factors impacting the decision of entrepreneurs to go for technology-based options (Allahyary & Meigounpoory, 2013).

Source: own study.

Further, the ISM approach was adopted to model and establish the directional relationship between the identified nine enablers for technology entrepreneurship. The ISM is a qualitative technique with a set of defined steps (Hassannezhad *et al.*, 2020; He & Pan,2019; Maleki & Hajipour, 2020; Sage, 1977; Warfield, 1974). The complete ISM methodology is described in detail below in steps 1-4 (Tables 5-9).

Table 4. Factors identified through literature review, factor analysis and expert opinion

Sr. No.	Enablers
1	Competitive advantage
2	Knowledge and experience of technology
3	More funding options for technology entrepreneurs
4	Better market opportunities
5	Supportive government policies
6	Personal interest
7	Attraction for financers
8	IPR benefits
9	Technology adoption by competitors

Source: own elaboration of Agrawal *et al.* (2017), Chaudhary and Sindhu (2015), Hassannezhad *et al.* (2020), He and Pan (2019).

Step 1: Factor identification for the study:

As discussed in the previous section, a set of nine factors were identified from the literature review, primary data collection, and expert opinion.

Step 2: Formation of Structural self-interaction matrix (SSIM):

SSIM was framed (Table 5) by identifying the 'influence' type of contextual relationship amongst the factor by using the following rule (He & Pan, 2019; Warfield, 1974):

V = Factor i will influence factor j;
A = Factor j will influence factor i;
X = Factor i and j influence each other; and
O = Factors i and j are not related to each other.

Table 5. Structural self-interaction matrix (SSIM)

Factors	E9	E8	E7	E6	E5	E4	E3	E2	E1
E1	X	A	V	V	O	V	O	O	
E2	O	V	V	X	A	O	A		
E3	V	A	V	V	A	X			
E4	V	A	V	V	A				
E5	V	V	V	V					
E6	A	A	A						
E7	V	A							
E8	V								
E9									

Source: own study.

Step 3: Formation of Final Reachability Matrix (Transitivity):

The SSIM formed in step 2 above was converted into a binary matrix by putting 1 for every (i,j) entry of V, X in SSIM and 0 for every (j, i) entry of V, X in SSIM; and similarly 0 for every (i,j) entry of A, O in SSIM and 1 for every (j, i) entry of A, O in SSIM entry respectively was termed as Reachability Matrix (Agrawal *et al.*, 2017; Mani *et al.*, 2016). Further, transitivities were included in the initial reachability matrix by following the rule that if factor R was influencing factor S, and factor S was influencing factor T, then factor R should hace influenced factor T as well. Accordingly, the final reachability matrix with transitivities, driving power, and dependence of each factor was summarized in Table 6.

Step 4: Carrying out level partitioning for the factors

Levels were identified for all the factors by carrying out step-by-step partitioning of the reachability matrix. For this purpose, reachability set (having the factors themselves and the factors that influence it) and antecedent set (having factor itself and its influence) were generated for each factor, and the intersection set was generated. Wherever intersection and reachability sets became equal, the level

was given to that factor, which was removed from further calculations (Agrawal *et al.*, 2017). In this study, a total of five iterations were required to get levels to all the factors (Table 7).

Table 6. Final reachability matrix (transitivity)

Factors	E1	E2	E3	E4	E5	E6	E7	E8	E9	Driving Power
E1	1	1*	0	1	0	1	1	0	1	6
E2	1	1	1*	1*	0	1	1	1	1*	8
E3	1	1	1	1	0	1	1	1*	1	8
E4	1*	1*	0	1	0	1	1	1*	1	7
E5	1	1	1	1	1	1	1	1	1	9
E6	0	0	0	0	0	1	0	0	0	1
E7	0	1*	0	0	0	1	1	0	0	3
E8	1	1*	1	1	0	1	1	1	1	8
E9	1*	1	0	0	0	1	1*	1*	1	6
Dependence	7	8	4	6	1	9	8	6	7	

Note: *denotes transitivity.
Source: own study.

Table 7. Consolidated level of factors

Factors	Reachability Set	Antecedent Set	Intersection Set	Level
E1	1,2,4,6,7,9	1,2,3,4,5,8,9	1,2,4,9	**III**
E2	1,2,3,4,6,7,8,9	1,2,3,4,5,7,8,9	1,2,3,4,7,8,9	**II**
E3	1,2,3,4,6,7,8,9	2,3,5,8	2,3,8	**IV**
E4	1,2,4,6,7,8,9	1,2,3,4,5,8	1,2,4,8	**III**
E5	1,2,3,4,5,6,7,8,9	5	5	**V**
E6	6	1,2,3,4,5,6,7,8,9	6	**I**
E7	2,6,7,9	1,2,3,4,5,7,8,9	2,7,9	**II**
E8	1,2,3,4,6,7,8,9	2,3,4,5,8,9	2,3,4,8,9	**IV**
E9	1,2,6,7,8,9	1,2,3,4,5,7,8,9	1,2,7,8,9	**II**

Source: own study.

The diagonal entries of the reachability matrix were converted to zero to develop the binary relationship matrix (Table 8).

Table 8. Binary relationship matrix

i,j	E1	E2	E3	E4	E5	E6	E7	E8	E9	Driving Power
E1	0	0	0	1	0	1	1	0	1	4
E2	1	0	0	0	0	1	1	1	0	4
E3	1	1	0	1	0	1	1	0	1	6
E4	0	1	0	0	0	1	1	0	1	4
E5	1	1	1	1	0	1	1	1	1	8
E6	0	0	0	0	0	0	0	0	0	0
E7	0	0	0	0	0	1	0	0	0	1
E8	1	0	1	1	0	1	1	0	1	6
E9	0	1	0	0	0	1	0	0	0	2
Dependence	4	4	2	4	0	8	6	2	5	

Source: own study.

The Fuzzy-MICMAC was chosen instead of MICMAC considering the point that MICMAC analysis deems only binary relationships (*i.e.,* 0 and 1) between the factors while Fuzzy-MICMAC identifies the qualitative relationship between the factors on a scale of 0-1 (Kumar *et al.*, 2019; Mohanty, 2018) as depicted in Table 9 and further discussed in this section.

Table 9. Possible numerical value of factor interrelationships

Relationship Possibilities	No	Very low	Low	Medium	High	Very high	Complete
Value	0	0.1	0.3	0.5	0.7	0.9	1

Source: own study.

The below-mentioned procedure was adopted to develop the Fuzzy-MICMAC matrix. Two of the subject experts were contacted to give factor interrelationships as per their understanding, and an average score for responses from both the experts was noted in the form of a Fuzzy-MICMAC matrix. The Fuzzy-MICMAC matrix was then multiplied using the fuzzy matrix multiplication rule, as stated below as formula (i):

$$C = A, B = \max k\ [\min(a_{ik}, b_{kj})] \text{ where } A = [a_{ik}] \text{ and } B = [b_{kj}] \quad (1)$$

Accordingly, the final standardized Fuzzy-MICMAC matrix so obtained (including the values of driving power and dependence) is placed as Table 10.

Table 10. Final standardized fuzzy MICMAC matrix

i,j	E1	E2	E3	E4	E5	E6	E7	E8	E9	Driving Power
E1	0	0	0	1	0	0.9	0.9	1	1	4.8
E2	0.9	0	0.1	0.1	0	1	0.9	0.7	0	3.8
E3	0.7	0	0	1	0	1	1	0	0.9	4.6
E4	0.5	0.3	1	0	0.3	0.9	1	0.1	1	5.1
E5	0.9	0.5	1	1	0	1	1	0.7	1	7.1
E6	0	0.7	0	0	0	0	0	0	0	0.7
E7	0	0	0.5	0.3	0	1	0	0	0.9	2.7
E8	1	0	1	1	0	1	1	0	1	6.0
E9	0.9	0.5	0.5	0.7	0	1	0.7	0.7	0	5.0
Dependence	4.9	2.0	4.1	5.1	0.3	7.8	6.5	3.2	5.8	

Source: own study.

RESULTS AND DISCUSSION

Technology entrepreneurship has been finding grounds to develop in a growing economy like India for two reasons. Firstly, since the early 2000s, Indian IT Industry has been booming with the growth of the electronic and defense industry. Secondly, India has witnessed a great improvement in its research facilities and education policies. Today, India boasts of its highly skilled human resources in science and technology. The other major factors contributing to the growth of technology entrepreneurship in India relate to improved government policies and the emergence of multinational firms in India, especially technology (Meil *et al.,* 2017). The technology ecosystem is improving remarkably in India. The government is developing infrastructural and policy support for the technology entrepreneurs. India's science, technology and innovation policy are improving the national knowledge base, subsidising and research and development, promoting industry-academia collaborations, improving technology flow, fostering the ecosystem for intellectual property rights Tripathi and Brahma (2018). The upcoming schemes by the Government of India will greatly benefit technology entrepreneurs in terms of technology incubators. The department of science and technology (DST) provides the institutional framework for promoting technology-based firms. This role is extensively played by Science & Technology Entrepreneurship Development Board (NSTEDB), promoting science and technology entrepreneurs park and the technology business incubators. The Indian government is surfacing success in motivating young entrepreneurs towards technology-based startup, which leads to the social and sustainable growth of the economy (CIS-India report).

Fuzzy MICMAC Diagram

Following the procedure described in the methodology section, the fuzzy-MICMAC Diagram and the ISM model obtained are discussed in this section. The driving power and dependence of each factor were plotted on the X and Y axis, and the Fuzzy-MICMAC diagram so obtained is placed in Figure 1.

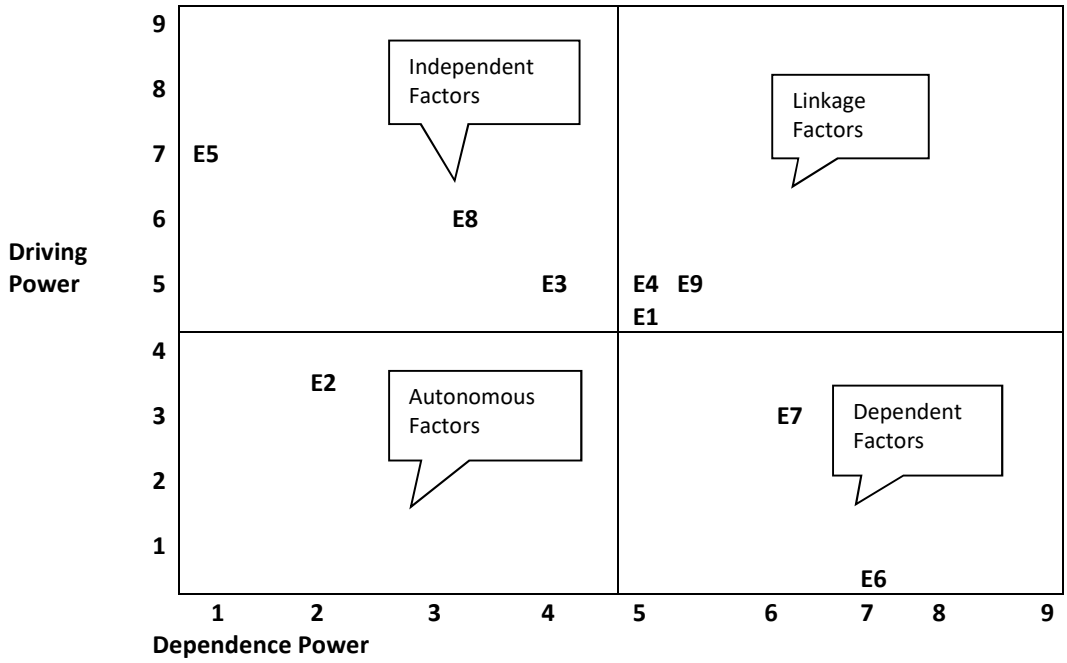

Figure 1. Fuzzy-MICMAC Analysis
Source: own elaboration.

The fuzzy-MICMAC diagram groups all the factors under study into four different clusters based on each factor's driving power and dependence. In this research, the factor viz. knowledge and experience of technology (E2) emerged in the first cluster, *i.e.*, 'autonomous factors' characterized by weak driving power and weak dependence. This factor usually remains disconnected from the system. Factors in the second cluster are 'dependent factors.' Factors in this cluster are characterized by very high dependence on other factors and weak driving power. Here, personal interest (E6) and attraction for financers (E7) emerged as dependent factors. These two factors depend on all other factors to successfully enable the adoption of technology entrepreneurship.

Factors in the third cluster are 'linkage factors' which are the most unstable, but they significantly impact other factors. Four factors emerged as linkage factors viz. competitive advantage (E1), better market opportunities (E4), and technology adoption by competitors (E9). Finally, the fourth cluster has the 'Independent factors,' which have strong driving power but weak dependence. Supportive government policies (E5) emerged as the most significant independent factor, followed by more funding options (E3), and IPR benefits (E8).

The ISM model is a diagrammatic reflection of interrelationships between the factors, as per the level identified for each factor (He & Pan, 2019). The model (Figure 2) reflects, Supportive Government Policies (E5) as the most significant driver, followed by More Funding Options (E3). These factors drive other factors to a great extent as enablers for technology entrepreneurship. If government policies favour entrepreneurs, they get more funding options and access to other resources. Getting timely and sufficient funding options drives entrepreneurs to take a technology-based startup initiative. These results are in line with previous studies, which advocate that the ecosystem for technology entrepreneurship needs to be developed and the policy framework needs to be strengthened (Sung *et al.*, 2015). The IPR benefits (E8) also emerged as the influencing force for other enablers. Entrepreneurs wish to protect their intellectual property from getting benefits from that. If government policies support IPR protections, entrepreneurs can reap the benefits. The study by (Maysami & Elyasi, 2020; Willie *et al.*, 2011) demonstrates the results in a similar way, in which the role of support facilities in the form of government, IPR, legal and financial support has highlighted the promotion of technology entrepreneurs.

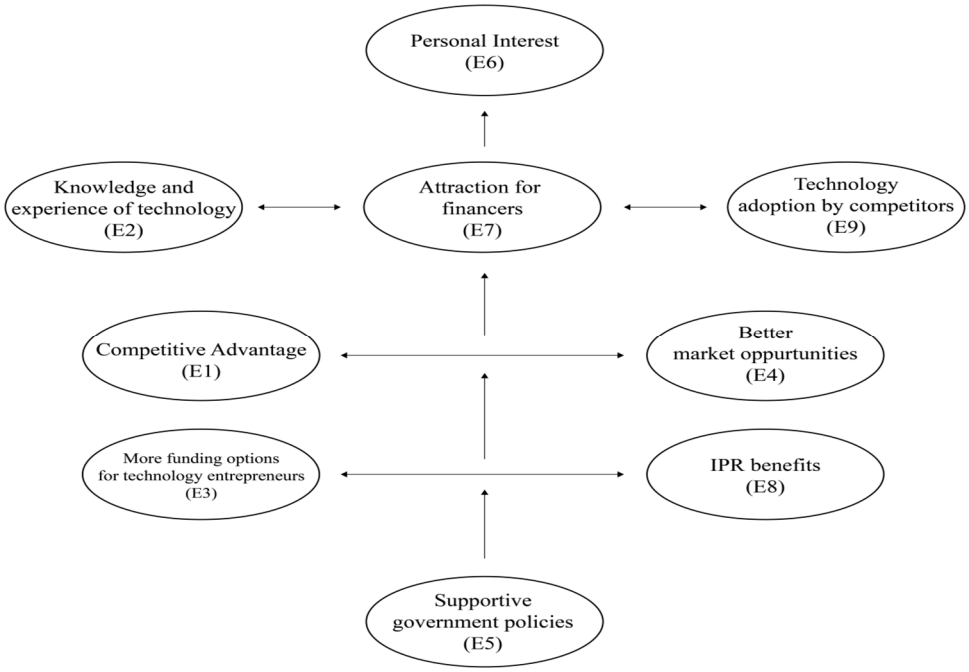

Figure 2. Diagraph of the ISM model development
Source: own elaboration.

In turn, the IPR benefits influence other factors like Competitive Advantage (E1). These days, many entrepreneurs wish to get associated with such businesses where they can get differentiation opportunities to stand ahead of their competitors. Gaining a competitive advantage through IPR protection helps an entrepreneur fetch Better Market Opportunities (E4). Entrepreneurs will adopt technology entrepreneurship only if they can see any scope for a better market or consumers. Furthermore, entrepreneurs get impacted by the moves and strategies of their competitors. If an entrepreneur finds Technology Adoption by Competitors (E9), then the entrepreneur also explores the option by choice or force. Similarly, Badzińska (2016) highlights that organizational factor and the external business environment impact the establishment of a technology entrepreneur.

Moreover, Knowledge and Expertise of Technology (E2) is one of the significant enablers for adopting technology entrepreneurship. Entrepreneurs may think about developing their skills or enhancing their knowledge about technical aspects if they get support from the driving forces like government support, funding opportunities, better market opportunities, competitive advantage, etc. Kankipati (2017) too suggested in their study that technology-related skills and knowledge are the base for a technology startup. These driving forces also become a reason for the technology startup's Attraction for Financers (E7). Financers find growth opportunities and promising financial models in such avenues. Eventually, all such enablers become a source of a significant driving force for entrepreneurs to develop Personal Interest (E6) for technology entrepreneurship. Therefore, an individual's interest is the most strategic factor deciding the success or failure of this model. Willie *et al.* (2011) also advocates similar outcomes. The authors proposed that a study in Nigeria projects that most entrepreneurs pursue technology-based startup either because of their interest or family motivation.

Practical Implications

This research significantly contributes to the industrial ecosystem for technology entrepreneurs. It highlights government and policy initiatives' established role in harnessing innovation and growth of technology in any ecosystem. One of the most significant contributing factors for the growth of technology entrepreneurship in India is improved government policies and the emergence of multinational firms in India, especially in technology (Meil & Salzman, 2017). The government of India is coming up with infra-

structural and policy support for the technology entrepreneurs. The DST provides an institutional framework for promoting technology-based firms. This role is extensively played by Science & Technology Entrepreneurship Development Board (NSTEDB) through the advancement of science and technology entrepreneurs park and the technology business incubators. The Indian government is surfacing success in motivating young entrepreneurs towards technology-based startup, leading to the social and sustainable growth of the economy (CIS-India report). Worldwide, companies take advantage of technology-enabled business models to impact value chains. The World Bank's framework proposed by Bessant *et al.* in 2000 (Rush *et al.*, 2007) advocates nine dimensions for evaluating companies' technological capabilities. The factors identified as enablers for technology entrepreneurship support the proposed framework. As depicted in Table 11, all the factors identified match with any one of the dimensions from the World Bank Framework, therefore justifying the need for enabling factors for the industrial ecosystem.

Table 11. Congruence between enabling factors and World Bank's framework

Sr. No.	Factor(s) identified	Matching dimension as per World Bank Framework
1	Competitive advantage	Core Competency
2	Knowledge and experience of technology	Awareness
3	More funding options	Search
4	Better market opportunities	Search
5	Supportive government policies	Linkages
6	Personal interest	Learning
7	Attraction for financers	Linkage
8	IPR benefits	Strategy
9	Technology adoption by competitors	Technology Paradigm

Source: own study.

This research further propagates that the individual attitude of an entrepreneur towards accepting new ideas for startup based on technology makes a huge difference to the complete industry, and that is where the role of small businesses is significant enough to mark the difference. Similarly, IPRs play a major role in developing a sustainable advantage for small technology-based startup (Preston, 2001). Indian science, technology, and innovation policy is working towards improving the national knowledge base, subsidizing and research and development, promoting industry-academia collaborations, improving technology flow, fostering the ecosystem for intellectual property rights (Tripathi & Brahma, 2018). The upcoming schemes greatly benefit technology Entrepreneurs for technology incubators by the Government of India. Moreover, the research highlights the role of quality investors in promoting technology startup. There is a need to rapidly get high-quality products to support technology adoption in small startup (Preston, 2001).

CONCLUSIONS

The growth of technology startup in an economy reflects development. Being a developing economy, India needs the support of budding entrepreneurs to make the country tech-savvy. Although many entrepreneurs show a strong inclination towards a technological startup, very few have a purely technology-based startup, with technology as the core. The most important drivers for adopting technology entrepreneurship are supportive government policies, which lead to better funding options for the entrepreneurs and support in getting IPR benefits. The strong drives, in turn, influence other underlying and related enablers like getting a competitive advantage for their business and having better market opportunities. Additionally, entrepreneurs realize the need for updated knowledge and skills related to technology. An increase in the push from the market forces and knowledge of the technology increases the probability of interest in opening the technological startup to the maximum extent. The strategies and technologies adopted by competitors also impact any entrepreneur's decision and financers' decision to support the technology entrepreneurs. Eventually, all such drivers influence the personal interest of an entrepreneur to get inclined towards technology entrepreneurship.

The article indicates the roadmap for market players and policymakers to shape the policies and resources in such a manner so that the budding entrepreneurs get sufficient support and motivation to go for purely technology-based startup. Hence, there is a need to emphasize the development of required market infrastructure and disseminate new knowledge and technology to establish and expand technology-based startup.

The key limitations include the amount of primary data, maybe because very few entrepreneurs consider technology as a core for their startup and mostly use technology as an enabler for their business. Future studies may focus on establishing a framework for the technology entrepreneur's ecosystem, the growth potential of a technology-based startup in developing Vs. developed nations, the digital divide of resource and knowledge availability for a small startup. Finally, future studies may consider qualitative tools for analysis.

REFERENCES

Agrawal, A. K., Kumar, D., & Rahman, Z. (2017). An ISM approach for modelling the enablers of sustainability in market-oriented firms. *International Journal of Business Excellence*, *12*(1), 23-45.

Aljuwaiber, A. (2020). Entrepreneurship research in the Middle East and North Africa: trends, challenges, and sustainability issues. *Journal of Entrepreneurship in Emerging Economies*, *13*(3), 380-426, https://doi.org/10.1108/JEEE-08-2019-0123

Allahyary, M. & Meigounpoory, M. R. (2013). New conceptual Model of Technology Entrepreneurship Process in Nano-food Science-based Technological Firms in Science and Technology Parks. *International Journal of Academic Research in Business and Social Sciences*, *3*(11), 284-304.

Asim, S., Li, C., Makhdoom, H. U., & Zafar, Z. (2019). Entrepreneurial Technology Opportunism and Its Impact on Business Sustainability with the Moderation of Government Regulations. *Entrepreneurial Business and Economics Review*, *7*(3), 161-185. https://doi.org/10.15678/EBER.2019.070309

Badzińska, E. (2016). The Concept of Technological Entrepreneurship: The Example of Business Implementation. *Entrepreneurial Business and Economics Review, 4*(3), 57-72, http://dx.doi.org/10.15678/EBER.2016.040305

Baier-Fuentes, H., Guerrero, M., & Amorós, J. E. (2021). Does triple helix collaboration matter for the early internationalisation of technology-based firms in emerging Economies? *Technological Forecasting and Social Change*, 1*63*, 120439, https://doi.org/10.1016/j.techfore.2020.120439

Bailetti, T. (2012). Technology entrepreneurship: overview, definition, and distinctive aspects. *Technology Innovation Management Review*, *2*(2), 5-12.

Bhardwaj, B.R. (2020). Adoption, diffusion and consumer behavior in technopreneurship. *International Journal of Emerging Markets*, *16*(2), 179-220, https://doi.org/10.1108/IJOEM-11-2018-0577

Chalmers, D., MacKenzie, N. G., & Carter, S. (2020). Artificial Intelligence and Entrepreneurship: Implications for Venture Creation in the Fourth Industrial Revolution. *Entrepreneurship Theory and Practice*, *45*(5), 1028-1053, https://doi.org/10.1177/1042258720934581

Chatterjee, S., Gupta, S. D., & Upadhyay, P. (2020). Technology adoption and entrepreneurial orientation for rural women: Evidence from India. *Technological Forecasting and Social Change*, *160*, 120236, https://doi.org/10.1016/j.techfore.2020.120236

Chaudhary, J., & Shilpa, S. (2015). Modeling the Enablers of Innovative Leadership: An ISM Approach. *International Journal of Innovations in Engineering and Management*, *4*(1), 65-74

Giacon, P. (2008). Rising of the new generation of high-tech entrepreneurs: an exploratory study. In *Proceedings of the 16th Annual High Technology Small Firms Conference 2008*, University of Twente.

Giones, F., & Brem, A. (2017). Digital Technology Entrepreneurship: A Definition and Research Agenda (May 27, 2017). *Technology Innovation Management Review*, *7*(5), https://ssrn.com/abstract=2984542.

Glukhikh, P., & Golovina, A. (2021). Strategies for Creating Technology Businesses by Serial Entrepreneurs as a Source of New Industrialization. In *3rd International Scientific Conference on New Industrialization and Digitalization*, Ekaterinburg, Russia, Dec. 12, 2020. 93(01023), https://doi.org/10.1051/shsconf/20219301023.

Hassannezhad, Z., Zali, M. R., Faghih, N., Hejazi, R. & Mobini, A., (2020). A Process Model of Entrepreneurial Alertness Among Technopreneurs. *International Business Research*, *13*(3), 1-96.

He, Y., & Pan, J. (2019). The multi-case analysis on the factors of source innovation: based on the ISM. In *2019 10th Int. Conf. on E-business, Management and Economics*, Beijing, China, July 15-17, 2019. 45-50, https://doi.org/10.1145/3345035.3345045.

Jafari-Sadeghi, V., Garcia-Perez, A., Candelo, E., & Couturier, J. (2021). Exploring the impact of digital transformation on technology entrepreneurship and technological market expansion: The role of technology readiness, exploration and exploitation. *Journal of Business Research*, *124*, 100-111.

Kamarudin, H. S., & Sajilan, S. (2013). Critical success factors of technopreneurship in the creative industries: A study of animation ventures. *Review of Integrative Business and Economics Research*, *2*(1), 1.

Kankipati, A (2017). An Empirical Study on Technology: Entrepreneurship Ecosystem in India. Retrieved from https://ssrn.com/abstract=3144166 on December 21, 2017.

Karyaningsih, R. P., Wibowo, A., Saptono, A., & Narmaditya, B. S. (2020). Does entrepreneurial knowledge influence vocational students' intention? Lessons from Indonesia. *Entrepreneurial Business and Economics Review*, *8*(4), 138-155, https://doi.org/10.15678/EBER.2020.080408

Kennett, G., & Sun, H. (2021). Stimulating the Growth of Technology-Based Incubators: Government as Enabler, La Trobe. *Paper for Greater China-Australia Dialogue on Public Administration November 2019*, https://doi.org/10.26181/60091af22a25a

Kumar, S., & Das, S. (2019). An extended model of theory of planned behaviour: Entrepreneurial intention, regional institutional infrastructure and perceived gender discrimination in India. *Journal of Entrepreneurship in Emerging Economies*, *11*(3) 369-391, https://doi.org/10.1108/JEEE-09-2018-0089

Kumar, H., Singh, M. K. & Gupta, M.P. (2019). A policy framework for city eligibility analysis: TISM and fuzzy MICMAC-weighted approach to select a city for smart city transformation in India. *Land Use Policy, 82*, 375-390, https://doi.org/10.1016/j.landusepol.2018.12.025.

Maleki, M. M. & Hajipour, B. (2021). Organizational antecedents model of sustainable entrepreneurial orientation: multi-case study of Iranian firms. *Journal of Entrepreneurship in Emerging Ecomies*, *13*(5), 1173-1191. https://doi.org/10.1108/JEEE-07-2020-0233

Mani, V., Agrawal, R. & Sharma, V. (2016). Impediments to Social Sustainability Adoption in the Supply Chain: An ISM and MICMAC Analysis in Indian Manufacturing Industries. *Global Journal of Flexible System Management*, *17*(135), https://doi.org/10.1007/s40171-015-0106-0

Maysami, A. M., Elyasi, G. M., Dehkordi, A. M. & Hejazi, S. R. (2019). Toward the Measurement Frame-work of Technological Entrepreneurship Ecosystem. *Journal of Enterprising Culture*, *27*(4), 419-444, https://doi.org/10.1142/S0218495819500158

Maysami, A. M., & Elyasi, G. M. (2020). Designing the framework of technological entrepreneurship ecosystem: A grounded theory approach in the context of Iran. *Technology in Society*, *63*, 101372, https://doi.org/10.1016/j.techsoc.2020.101372

Meil, P., & Salzman, H. (2017). Technological entrepreneurship in India. *Journal of Entrepreneurship in Emerging Economies, 9*(1), 65-84.

Mohanty, M. (2018). Assessing sustainable supply chain enablers using total interpretive structural modeling approach and fuzzy-MICMAC analysis. *Management of Environmental Quality*, *29*(2), 216-239. https://doi.org/10.1108/MEQ-03-2017-0027

Mollaei, L. & Gelard, P. (2016). The Effects of Research and Development on Technology Entrepreneurship in Small and Medium-Sized Businesses in Iranian Nanotechnology Companies. *Journal of Administrative Management, Education and Training*, *12*(2), 89-99.

Nacu, C. M., & Avasilcăi, S. (2014). Environmental factors influencing technological entrepreneurship: research framework and results. *Procedia-Social and Behavioral Sciences*, *109*, 1309-1315.

Nazarov, M., Butryumova, N. & Sidorov, D. (2017). Development of technology entrepreneurship in a transition economy: An example of the russian region with high scientific potential. *DIEM: Dubrovnik International Economic Meeting*, *3*(1), 89-104.

Pathak, S., Xavier-Oliveira, E. & Laplume, A. O. (2013) 'Influence of intellectual property, foreign investment, and technological adoption on technology entrepreneurship'*, Journal of Business Research, 66*(10), 2090-2101.

Petti, C., & Zhang, S. (2011). Factors influencing technological entrepreneurship capabilities: Towards an integrated research framework for Chinese enterprises. *Journal of Technology Management in China*, *6*(1), 7-25, https://doi.org/10.1108/17468771111105631

Preston, J. T. (2001). *Success factors in technology-based entrepreneurship*, Massachusetts Institute of Technology, MIT Entrepreneurship Center. Retrieved from: https://www.angelcapitalassociation.org/data/Documents/Resources/AngelGroupResarch/1d%20-%20Resources%20-20Research/31%20Research_Entrepreneurship.pdf?rev=41C9 on March 18, 2021

Roberts, E. B. (1991). *Entrepreneurs in high technology: Lessons from MIT and beyond*, Oxford University Press.

Rush, H., Bessant, J., & Hobday, M. (2007). Assessing the technological capabilities of firms: developing a policy tool. *R&D Management*, *37*(3), 221-236.

Sage, A. P. (1977). *Interpretive Structural Modeling: Methodology for Large-Scale Systems*, New York: McGraw-Hill.

Sanjaya, R., Soekesi, A. E., & Sitohang, A. P. (2015). Technology entrepreneurship model development for teachers. *International Journal of Technoentrepreneurship*, *3*(1), 60-66.

Shane, S., & Venkataraman, S. (2003). Guest editors' introduction to the special issue on technology entrepreneurship. *Research Policy*, *32*(2), 181-184.

Sung, C. S., Joo, H. J., & Park, J. Y. (2015). Strategies of fostering technology entrepreneurship for the foundation of entrepreneurial ecosystem. *International Information Institute (Tokyo). Information*, *18*(5), 1545.

Centre for Internet and Society. (2015). *Technology Business Incubators: An Indian Perspective & Implementation Guidance Repor*. Centre for Internet and Society, India. Retrieved from: https://cis-india.org/internet-governance/blog/technology-business-incubators.pdf on February 24, 2020

Tripathi, S., & Brahma, M. (2018). Technology Entrepreneurship in Emerging Markets: An Exploration of Entrepreneurial Models Prevalent in India. *Technology Innovation Management Review*, *8*, 24-32.

Venkataraman, S. (2004). Regional transformation through technological entrepreneurship. *Journal of Business venturing*, *19*(1), 153-167, https://doi.org/10.1016/j.jbusvent.2003.04.001

Villegas-Mateos, A. (2020). Regional entrepreneurial ecosystems in Chile: comparative lessons", *Journal of Entrepreneurship in Emerging Economies*, *13*(1), 39-63, https://doi.org/10.1108/JEEE-11-2019-0168

Warfield, J.W. (1974). Developing interconnected matrices in structural modelling. *IEEE Transactions on Systems Men and Cybernetics*, *4*(1), 51-81.

Willie O. S., Helen O. A., Abiodun A. E. & Sanni M. (2011). Framework for technological entrepreneurship development: key issues and policy directions**.** *American Journal of Industrial Business Management, 1*(1), 10-19. https://doi.org/10.4236/ajibm.2011.11002

Yami, S., M'Chirgui, Z., Spano, C., & Gontier B., O. (2021). Reinventing science and technology entrepreneurship education: The role of human and social capitals. *Technological Forecasting and Social Change*, *164*(C).

Authors

The contribution share of authors is equal and amounted to 50% for each of them. SS – conceptualisation, literature writing, methodology, analysis. RSM – analysis, review, editing. The final manuscript was approved by both authors.

Shilpa Sindhu
Associate Professor of marketing and entrepreneurship at School of Management and Liberal Studies, The NorthCap University, Gurugram India. PhD in Business Administration. Her area of specialization is marketing with interest in consumer behaviour, entrepreneurship, e-commerce, retail marketing, services marketing.
Correspondence to: Dr. Shilpa Sindhu, School of Management, The NorthCap University, Gurugram, Haryana, India, e-mail: shilpasindhu@ncuindia.edu
ORCID http://orcid.org/0000-0003-2825-1744

Rahul S Mor
PhD specializing in supply chain & operations management. A faculty and researcher of operations management, supply chain & logistics, industrial engineering & management, as well as manufacturing systems. Authored/co-authored over 50 publications in international refereed SCI, ABDC, CABS ranked journals of high impact.
Correspondence to: Dr. Rahul S Mor, Department of Food Engineering, National Institute of Food Technology Entrepreneurship and Management, Kundli (Sonepat) – 131028, India, e-mail: dr.rahulmor@gmail.com
ORCID http://orcid.org/0000-0002-3481-5430

Acknowledgements and Financial Disclosure

The authors are thankful to their parent institutes (The Northcap University, Gurugram, Haryana, India, and National Institute of Food Technology Entrepreneurship and Management, Kundli, Sonepat, India) for providing support and essential facilities to conduct this research work smoothly. No funding was received to conduct this research.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright and License

Published by Cracow University of Economics – Krakow, Poland