Application of Fuzzy Analytic Hierarchy Process in Prioritizing and Ranking Critical Success Factors of Innovation Startups

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Abtract: -The objective of this study is to investigate the Key Success Factors (KSF) and their relative importance on the success of innovation startups in Vietnam context. Seventeen factors (indicators) were identified through the extensive literature review. The indicators were then grouped into four categories including *Individuals, Organizational, Externals* and *Product and Market*. A group of fourteen experts were formed and asked to prioritize the factors and indicators. The fuzzy analytic hierarchy process (FAHP) were subsequently utilized to determine the relative weights of factors and indicators in contributing to the success of innovation startups. The results show that the factors have different levels in influencing the success of startups, with *Individuals* being more important than the others. Regarding the overall impact on the success of startups, the most influential factors are entrepreneurial characteristics including *Initial motivation, Experience in the industry* and *Academic formation*.

Key-Words: - Fuzzy AHP; Entrepreneurship; Innovation; Critical Success Factors.

1. Introduction

In recent years, "Startup" and "Industrial Revolution 4.0" have become “hot” topics in various nations and regions. In Vietnam, 2016 was selected as the year of startups. According to statistics of the Ministry of Planning and Investment, Vietnam had more than 110,000 newly established enterprises with the capital of over VND 800,000 billions in 2016. In 2017, 126,859 enterprises with a total capital of VND 1,295.9 trillion were registered to open. The numbers of registered enterprises and registered capital had respectively increased by 15.2% and 45.4% in comparion with those in 2016. There are no official statistics on the number of failed startups in Vietnam; however, in Vietnam, it is supposed that there are up to 90% of failed startups. The number of failed startups is too high compared to that in the US (only 25% failed after two years and 52% failed after four years) [1]. According to an VCCI report (2018), in 2017, the abandonment rate of start-up businesses is 18% and the innovation index of Vietnam is still low compared to those of other countries with the same level of development. Only 13.9% of Vietnamese enterprises in the start-up phase have been considered as new innovative enterprises compared to 21% of those in countries at the same level of development and Vietnam has been ranked 48 among 54 countries and economies participated in the survey. Particularly, the technological, product and market innovation factors of Vietnam are 13.4%, 7.5%, and 3.5%, respectively. Therefore, creative entrepreneurship needs to paid more attention in startup activities in Vietnam.

In academic research, studies on creative entrepreneurship play an important part of entrepreneurial research. It is indicated that creative entrepreneurship is a study branch among four main ones within entrepreneurship research (based on the exploitation of business opportunities, the formation of new business entities, the creation of value or innovation) [2]. However, the number of studies related to creative start-ups is still limited when compared to other research topics in the start-up. It is also showed that studies on innovative models have been mainly focused on large enterprises, based on empirical research and often excluded small enterprises in their research [3].

Key success factors (KSFs) in startups are the factors that help identify the most important issues that need to be addressed in order to implement a successful start-up and make startup enterprises developed. There have been various studies on the topic, however, the factors are very diverse and the factor order is different in different research contexts [4]. Key success factors when prioritized may help entrepreneurs and start-up managers recognize important issues that lead to business success. Therefore, it is expected that this study may explore the key success factors of creative entrepreneurship and the priority of the factors in the context of Vietnamese entrepreneurship.

The objective of this study is to determine the order of key factors leading to the success of innovative entrepreneurship in Vietnam by Fuzzy AHP. AHP is a method developed by Saaty (1980) to solve complex decision-making problems with a variety of selection criteria and a wide range of decision-makers. Basically, AHP uses information or expert opinions to determine the relative importance or contribution of attributes and to synthesize an optimal selection solution. Although AHP is usually strong enough to explain and describe expert knowledge, it can not adequately and fully reflect human behavior and thought [5]. Thus, the fuzzy AHP, a fuzzy extension of AHP, was developed to solve the fuzzy decomposition problem. In the fuzzy AHP process, pairwise comparisons in matrices are fuzzy numbers. Therefore, decision makers can assign priorities in the form of natural language expressions on the importance of each criterion [6]. Thus, fuzzy logic provides a systematic basis for handling unclear or unclear situations [7]. For mentioned reasons, the fuzzy AHP method is a suitable approach to identify key success factors in a clear and scientific way.

The paper is organized as follows. After introduction, the literature review is provided in Section 2. Section 2 presents methodology; Section 4 is devoted to results and discussion. Finally, Section 5 concludes the study.

2. Literature Review

2.1. Creative startup

Creative startup deals with entrepreneurship, in which innovation is an essential part of the start-up process. A specialized keyword in English used to refer to a startup is "startup" or "innovation startup," referring to new business activities conducted by individuals or groups based on the exploitation of assets. Intellectual, technology or new business model and potential/ growth potential. So "startup" is often understood in terms of Information Technology Startup, New Technology-Based Venture and is in the phase of calling for funds from investment funds.

In this study, we only consider innovative/creative startups with broader range. This is an important topic of startup research, but the number of studies related to start-up innovation is still limited compared to other research topics in start-up domain [2]. It was explained by the fact that research on innovative/innovative models commonly focused on large enterprises, based on empirical research and often excluded small enterprises [3]. Where there have the innovative activities, creativity must be mentioned. The VCCI Business Start Index study [8] - based on the Global Entrepreneurship Monitor (GEM), addressed three major innovations including technology, products and markets. Innovation activities were defined and grouped into five major categories, including introducing consumers to an unknown product or new product quality; introduce a new production method having not seen in the industry; open a new market; use or create new sources of raw materials and intermediate products; a new form of organization in the industry [9]. Moreover, innovation is a process that brings added value and innovation to an organization, suppliers and customers by developing new processes, procedures, solutions, products, services, commercialization methods and/or new business models [10].

2.2. Key success factors

Key success factors (KSFs) means the key factors that help startups succeed. Various factors are discussed and demonstrated in various empirical studies. Based on the deep literature review of 1,013 paper and 74 empirical studies, the factors influencing the success of creative entrepreneurship have been systematized, and finally presented 21 success factors [4]. These factors were grouped into three main categories related to entrepreneurship, start-up and external environment, and other factors (group 4). Our study is mainly based on the findings of the

mentioned study to construct the research model that includes four groups of factors influencing the success of innovative entrepreneurship.

Group 1 is the factor that belongs to entrepreneurs - individuals. The individual's category represent the challenges related to the human capital of the startup (the entrepreneur leader and the work team). The connection between the human capital of a company and the business success has been studied in many works. The findings establish a strong positive connection, especially when the human capital that is involved in the company is well trained and has the necessary experience. In the organizational category (Group 2), also called organizational factors, the studies have been focused on factors such as the organizational age and the organizational size. The role of the location of the company is also considered as a facilitating factor for success because it allows the startup to be closer to the providers but especially close to the final clients. In addition, it is known that partners are important for the survival and growth of the startups. The externals category (Group 3) is also called characteristics of the environment where the startups operate. It was pointed out that the external factors can work/act/serve as the driving force behind the performance and growth of the organization. It was known that many times the success of a company can be influenced by factors foreign to the company such as the competitive rivalry, innovation, changes in the processes and technologies. Moreover, a better financial capacity gives the startup a better agility in the change of product and technology and these then results in a better adjustment/adaptation to the demand of the client. The lack of financing is often one of the reasons entrepreneurs give up on their business initiatives. Group 4 refers to product and market factors including the level of innovation of the product; the technology of the product; untapped potential of the market; growth rate of the market. These categories (groups) and key success factors (indicators) with their definitions are shown in Table 1.

Table 1: Key success factors for the success of the startup.

Category	Factor (indicator)	Definition
Individuals (IN)	Experience in the industry	Founders with previous experience in the industry have a solid network of contacts that facilitate the development and growth of the company.
	Academic formation	It is the academic preparation in courses of management of the founding team, which has a positive impact on organizational growth.
	Experience in management of the entrepreneur	It is the experience of the entrepreneur in organization and general management of the resources necessary to bring success to the company. It also describes the degree of competencies (attitudes, skills or abilities) of the entrepreneur to meet the objectives and goals
	Leadership	They are the characteristics and abilities of the entrepreneurial leader to lead the organization to fulfill its objectives.
	Initial motivation	The motivation of the founder represents his commitment to the project or idea of company.
Organizational (IO)	Organizational size	It is the number of founding employees of the startup, it is considered that the bigger the size of the entrepreneurial team, the greater the talent.
	Location	It is the geographic location of the startup in a given location, being closer to its suppliers and customers facilitates growth.
	Clustering	Group of interrelated companies that work in the

Category	Factor (indicator)	Definition
		same industrial sector and that collaborate strategically to obtain common benefits.
	Partner	It is a person or company with which an agreement, agreement or alliance is maintained.
Externals (EO)	Government support	It is the financial sponsorship of the government, through seed capital, in the initial stage of startup, are also support programs made, especially for startup.
	Venture capital	It is the entrepreneurial capital that consists of financing startup in the phase of growth with high potential and risk.
	Level of competence	It is the intensity of competition between Startups within the same industry.
	Science and technology policy	Political authorities give laws for the development of science and technology.
Product and Market (PM)	Product Innovation	Degree in which new innovative products and/or services are introduced.
	Product technology	Degree in which new innovative products design, such as software and high technology applications.
	Potential untapped market	They are emerging markets or market segments that have not seen product offerings.
	Market growth rate	Degree in which the average sales of the company increase, with respect to the industry.

Partly derived from Santisteban và Mauricio (2017)

3. Methodology

3.1. Data collection

In total, 15 experts including entrepreneurs, managers, experts from associations and universities were chosen to participate in the survey. Among these experts' answers, 5 questionnaires contained inconsistent answers. These inconsistent questionnaires were sent back to the respondents to be filled out again, whereupon 1 expert refused to revise and correct their responses. Consequently, this answer was excluded from the data analysis. Therefore, the result of this study is based on the responses of 14 experts. Table 2 presents the background of the study's respondents

Table 2: The background of the respondents.

No	Occupational areas	Current position	Years of Experience
1	Business	Businessman - Director	10
2	Business	Businessman - Director	6
3	Business	Businessman - Director	8
4	Business	Businessman - Director	9
5	Business	Businessman - Director	5
6	Business	Businessman - Director	7
7	Business	Businessman - Director	8
8	Business	Businessman - Director	12
9	Business	Businessman - Director	15
10	Association of Enterprises	Expert	15

No	Occupational areas	Current position	Years of Experience
11	Association of Enterprises	Expert	10
12	Academia	Dean of Business and Management Faculty	15
13	Academia	Dean of International Trade Faculty	20
10	Academia	Dean of Tourism Faculty	20
14	Academia	Dean of Information Technology Faculty	20

3.2. Rating scale

In order to collect data for fuzzy AHP evaluation, experts were asked to compare pairs of 4 categories of factors (*Individuals, Organizational, Externals, Product and Market*). Then, they were requested to compare pairs of indicators in each group. The rating scale used in survey is provided in Table 3 as follows:

Table 3: Five point scale used in questionnaire.

Linguistic variable	Numerical rating
Extremely importance	5
Very strongly importance	4
Strongly importance	3
Moderately importance	2
Equally importance	1

The categories of factors and indicators are shown in Table 4.

Table 4: Categories and factors (indicators).

Category	Factor (indicator)	Code
Individuals (IN)	Experience in the industry	IN1
	Academic formation	IN2
	Experience in management of the entrepreneu	IN3
	Leadership	IN4
	Initial motivation	IN5
Organizational (IO)	Organizational size	IO1
	Location	IO2
	Clustering	IO3
	Partner	IO4
Externals (EO)	Government support	EO1
	Venture capital	EO2
	Level of competence	EO3
	Science and technology policy	EO4
Product and Market (PM)	Product Innovation	PM1
	Product technology	PM2
	Potential untapped market	PM3
	Market growth rate	PM4

3.3. Data analysis by FAHP

Analytic hierarchy process (AHP) [5] is a powerful management science tool that successfully solves many multiple criteria

decision problems. The main steps in the application
of AHP are:

i) Structuring a decision problem in a hierarchy with different levels,

ii) Determining the local priorities at each level of the hierarchy, and

iii) Calculating the global priorities of the decision alternatives.

In the pure AHP, the relative importance of decision elements is evaluated from comparison judgments which are represented as crisp values. However, in many cases, the human preference is uncertain and decision makers usually feel more confident utilizing linguistic variables rather than expressing their judgments in the form of numeric values. In order to deal with more decision making problems in real situations, the fuzzy set theory was incorporated into AHP. Being an extension of AHP, fuzzy AHP is able to solve the hierarchical fuzzy decision-making problems. Since its appearance, the fuzzy AHP method has been widely used by many researchers to solve different decision making problems in various areas, such as selection, evaluation, resource allocation, planning and development. There are several fuzzy AHP methods; however, the extent analysis approach based on triangular fuzzy numbers for pairwise comparison is the most popular method. In our research, the extent analysis method was utilized calculate the relative weights of factors in contributing to the success of innovation startups.

4. Results and Discussions

In this study for the convenience of respondents, the linguistic scales used in this study are presented in Table 5.

Table 5: Linguistic scales and variables.

Linguistic scale	Satty's scale of relative importance	Triangular fuzzy scale (l, m, u)
Extremely importance	5	(9/2, 5, 11/2)
Very strongly importance	4	(7/2, 4, 9/2)
Strongly importance	3	(5/2, 3, 7/2)
Moderately importance	2	(3/2, 2, 5/2)
Equally importance	1	(2/3, 1, 3/2)

Table 6 shows the importance of the categories of factors evaluated by the experts. The results are expressed in the matrix form.

Table 6: Comparison matrix of the factors.

	IO	IN	EO	PM
IO	(1, 1, 1)	(0.71, 1.06, 1.69)	(0.40, 0.44, 0.62)	(0.45, 0.64, 0.72)
IN	(0.59, 0.85, 1.42)	(1, 1, 1)	(0.63, 0.71, 0.94)	(0.49, 0.68, 0.93)
EO	(1.62, 2.27, 2.53)	(1.06, 1.41, 1.59)	(1,1,1)	(1.24, 1.55, 1.91)
PM	(1.42, 1.57, 2.23)	(1.07, 1.46, 2.04)	(0.52, 0.65, 0.81)	(1,1,1)

The next step is to compute the local weight for each indicator. The below calculation method shows how the environmental factor (IO) be calculated.

$$S_L = \frac{1+0.71+0.4+0.45}{(1+0.71+0.4+0.45)+(1+1.42+2.53+2.23)+2+(0.63+1/0.63)+(0.49+1/0.49)+(1.91+1/1.91)} = 0.135$$

$$S_M = \frac{1+1.06+0.44+0.64}{1+1.06+0.44+0.64+0.85+1+0.71+0.68+2.27+1.41+1+1.55+1.57+1.46+0.65} = 0.192$$

$$S_U = \frac{1+1.69+0.62+0.72}{(1+1.69+0.62+0.72)+(1+0.59+1.62+1.42)+2+(0.94+1/0.94)+(0.93+1/0.93)+(1.24+1/1.24)} = 0.21$$

Among various ranking methods, Liou and Wang method [11] is the most commonly used in solving various practical problems. In brief, it is supposed that there are n fuzzy triangle numbers A_i, $i = 1, 2,.., n$. The sum value for each fuzzy $A_i = (l_i, m_i, u_i)$ is given by:

$$S^{\alpha}(A) = \left(\frac{1}{2}\right)\left[(u_i - l_i)\alpha + (l_i + m_i) - 2X_{\min}\right]$$

where $X_{min} = inf \cup_{i=1}^{n} \{x = \mu A_i(x) > 0\}_{\alpha} \in [0,1]$ can be considered as a stable or fluctuating condition, when $\alpha = 0$ means the decision-maker is pessimistic, when $\alpha = 1$ denotes the decision-maker is highly optimistic and $\alpha = 0.5$ expresses that the attitude is fair. When $X_{min} = 0$, the calculation is followed Liou and Wang's equation. Take the calculation of IO category as an example.

$$S^{\alpha}(IO) = \left(\frac{1}{2}\right)\left[(0.21 - 0.135)\alpha + (0.135 + 0.192) - 2.0.135\right] = 0.0375.\alpha + 0.057$$

let $\alpha = 0.5$, we obtain $S^{\alpha}(IO) = 0.0757$

Table 7: Rankings and local weights of indicator.

Category	Indicator	Code	Local weight	$S^{\alpha}(Fj)$	Ranking
Individuals (IN)	Experience in the industry	IN1	(0.22,0.33,0.40)	0.154	2
	Academic formation	IN2	(0.25,0.35,0.42	0.142	4
	Experience in management of the entrepreneur	IN3	(0.21,0.30,0.43)	0.145	3
	Leadership	IN4	(0.27,0.35,0.44)	0.122	5
	Initial motivation	IN5	(0.28,0.39,0.46)	0.155	1
Organizational (IO)	Organizational size	IO1	(0.14,0.17,0.29)	0.0676	2
	Location	IO2	(0.15,0.19,0.26)	0.0675	3
	Clustering	IO3	(0.20,0.22,0.27)	0.0375	4
	Partner	IO4	(0.11,0.20,0.26)	0.1275	1
Externals (EO)	Government support	EO1	(0.22,0.32,0.41)	0.1475	1
	Venture capital	EO2	(0.20,0.29,0.38)	0.135	2
	Level of competence	EO3	(0.24,0.32,0.39)	0.1175	3
	Science and technology policy	EO4	(0.21,0.29,0.31)	0.105	4
Product and Market (PM)	Product Innovation	PM1	(0.25,0.36,0.43)	0.155	2
	Product technology	PM2	(0.23,0.35,0.40)	0.1625	1
	Potential untapped market	PM3	(0.22,0.33,0.41)	0.1574	4
	Market growth rate	PM	(0.20,0.31,0.	0.1	3

Category	Indicator	Code	Local weight	S^{α}(Fj)	Ranking
		4	39)	575	

Table 7 shows that for the *Individuals* factor group, there is no disparity between indicators. However, *Initial motivation* is most important (S^{α} = 0.155), followed by *Experience in the industry* (2nd); *Experience in management of the entrepreneur* (3rd) and *Academic formation* (4th). For the *Individuals* factor group, the least important factor is *Leadership*. For *Organizational* factor, the *Partner* indicator has the most significant coefficient with S^{α} = 0.1275, which is four times higher than the *Clustering* indicator and twice as much as the other two indicators including *Organizational size* and *Location*. For *Externals* factor group, the ranking of the indicators in this group has a significant difference, in which *Government support* is the most important indicator (S^{α} = 0.1475), the second is *Venture capital*, the third is *Level of competence* and the fourth is *Science and technology policy*. For *Product and Market* indicators, the *Product technology* is the most important (S^{α} = 0.1625), the second is *Product Innovation*. The third is *Market growth rate* and the fourth is *Potential untapped market*.

In order to further clarify the rankings of the groups of factor influencing the success of the startup, Table 8 shows the rank order of each group.

Table 8: Rankings of category of factors.

Category	Code	Local weight	S^{α}(Fj)	Ranking
Individuals (IN)	IN	(0.26,0.36,0.47)	0.1525	1
Organizational (IO)	IO	(0.135,0.192,0.21)	0.0757	4
Externals (EO)	EO	(0.21,0.31,0.39)	0.145	2
Product and Market (PM)	PM	(0.23,0.32,0.43)	0.14	3

Table 8 reveals that the *Individuals* factor has the highest coefficient of influence with S^{α} = 0.1525, followed by *Externals* factor with S^{α} = 0.145, the third place is *Product and Market* with S^{α} = 0.14. It should be noted that the experts did not appreciate the role of the factors belonging to the *Organizational*, so among the four groups the *Organizational* group was ranked the last with the smalest S^{α} = 0.0757.

To assess the overall coefficients for the indicators, the overall index for each indicator needs to be determined. The total index indicates the contribution of each indicator to the overall goal (the success of the startup). The total index of each indicator in the hierarchical structure is computed by multiplying the fraction index with the index of the upper factor. For example, the total index IO1 indicator can be calculated as (0.14, 0.17, 0.29) * (0.135, 0.192, 0.21) = (0.027, 0.036, 0.061).

Table 9: Ranking and global weights.

Indicator	Code	Global weight	S^{α} value	Ranking
Experience in the industry	IN1	(0.057,0.118,0.188)	0.094	2
Academic formation	IN2	(0.065,0.126,0.197)	0.094	3
Experience in management of the entrepreneur	IN3	(0.546,0.108,0.202)	0.090	4
Leadership	IN4	(0.070,0.126,0206)	0.089	5
Initial motivation	IN5	(0.072,0.140,0.216)	0.103	1
Organizational size	IO1	(0.027,0.036,0.061)	0.017	17

Location	IO2	(0.028,0.039,0.055)	0.017	15
Clustering	IO3	(0.038,0.046,0.057)	0.012	16
Partner	IO4	(0.021,0.042,0.055)	0.029	14
Government support	EO1	(0.046,0.099,0.159)	0.081	8
Venture capital	EO2	(0.042,0.089,0.148)	0.074	9
Level of competence	EO3	(0.050,0.099,0.152)	0.074	12
Science and technology policy	EO4	(0.042,0.089,0.120)	0.065	13
Product Innovation	PM1	(0.057,0.115,0.185)	0.089	6
Product technology	PM2	(0.059,0.112,0.172)	0.080	10
Potential untapped market	PM3	(0.048,0.105,0.176)	0.089	7
Market growth rate	PM4	(0.053,0.099,0.167)	0.075	11

Table 9 indicates that the *Initial motivation* has the greatest impact on successful start-ups with S^{α} = 0.103, *Experience in the industry* and *Academic formation* ranked second and third among indicators. The next most important factors influencing the success of the startup include *Experience in management of the entrepreneur* (4th), *Leadership* (5th). *Product Innovation* (6th) (Note that at the local indicator this indicator stands behind *Product technology* indicator). This is noteworthy because the degree of influence between the local index and the global index has been changed. *Potential untapped market* ranked the 7th (in the local index, this indicator is behind *Market growth rate*). The other ranks are as follows: *Government support* (8th), *Venture capital* (9th), *Product technology* (10th), *Market growth rate* (11th), *Level of competence* (12th), *Science and technology policy* (13th), *Partner* (14th), *Location* (15th), *Clustering* (16th) and *Organizational size* (17th).

With the rank order change between the two tables, it is shown that the magnitude of local and global impact vary. This needs to consider when analyzing the role of indicators for their impact on key factors and simultaneously affecting the overall goal.

5. Conclusions

The objective of this study is to investigate the factors and their impact on the success of entrepreneurship. Through the intensive literature review, 17 indicators were identified. The indicators were grouped into four categories including *Individuals*, *Organizational*, *Externals* and *Product and Market*. The research findings show that among the four main categories, the *Individuals* (entrepreneur) has the largest influence on the success of a startup. Regarding the impact of the indicators on the overall goal (the success of the startup) also shows that the three most important factors are *Initial motivation*, *Experience in the industry* and *Academic formation* of entrepreneur. Otherwise, the least influential factors are *Organizational size* and *Clustering*. The findings of this research are consistent with previous studies related to evaluating and ranking success factors in entrepreneurship by consolidating the influence of personal characteristics of the founders [12]. Also, *Product and market* factor has been proposed in [13, 14]. The role of *Government support* and *Venture capital* in the

success of the startup have been confirmed by [15] and [16].

Whereas, the research findings did not confirm the large infuence of organizational-related indicators, although a number of previous studies have demonstrated the influence of them, i.e, [17-19]. Therefore, organizational-related indicators should be paid more attention in further research. One limitation of the study is the sample size is relative small, only 14 respondents. Moreover, in the survey, different participants did not have the same understanding of "the success of a startup", that is also supposed to be improved in our future research.

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