

Identifying and Prioritizing Factors Affecting Innovation of Investee Companies From the Perspective of Venture Capitalists: A Case Study

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Abstract

Nowadays innovation is one of the vital success factors of new SMEs. Venture capital can promote the innovation of investee firms. This paper aims to identify and prioritize factors affecting the innovation of investee firms. Initially, by reviewing the literature, 18 factors were extracted. Then by statistical analysis, six factors with less importance were removed. The 12 factors with more importance advanced to the final step to be prioritized by Fuzzy DEMATEL method. Results demonstrated that the most important factors are providing valuable information from the industry, cooperation and contact with the industry activists, and informing about the possible threats and opportunities. The findings of this paper provide key insight into alternative investment, which is a novel area in Iran's emerging financial markets. In other words, it can support both sides of a venture capital investment process to know which factors are of more importance to boost the possibility of success.

Keywords: venture capital, alternative investment, innovation, fuzzy DEMATEL.

1. Introduction

Innovation is the promotion of new ideas or behaviors in organizations that can appear in the novel product, service, production method, organizational structure, or governing system (Pérez-Luño et al., 2011). Innovation has become one of the main issues in many countries because these countries have found out that they can promote businesses and their economies by innovation. Baron and Tang (2011) consider innovation as a key element for a firm's success in its initial step.

Venture Capitals (VCs) can increase innovation (Chemmanur et al., 2011; Conti et al., 2019; Hood, 2000; Hsu, 2006; Maas et al., 2020; Wen et al., 2018). Chemmanur et al. (2011) suggest that venture capital investment can increase the firms' innovation and productivity. Venture capital investments are crucial to small and innovative companies because these investments have a positive and significant effect on their survival, growth, and prosperity (Nguyen & Vo, 2021). Since VCs have a key role in flourishing innovation and growth, many countries have adopted policies to develop the VC market (Bustamante et al., 2021). Many prestigious firms, such as Amazon, Apple, Facebook, Gilead Sciences, Google, Intel, Microsoft, Starbucks, and Whole Foods, which have had a huge effect on the world economy, are supported by venture capital (Gompers et al., 2020).

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VCs provide both financial and non-financial support for entrepreneurial firms. This support improves the success chance of the firms (Chemmanur et al., 2011). VCs take part in the backed ventures' managerial decisions, usually by membership in their board of directors (Sahlman, 1990). By and large, VCs are skilled at screening and contracting. They are also able to advise the investee firm on specific markets in which they invest (Peneder, 2014). VC-backed firms display higher efficiency compared to non-VC-backed firms in the same period (Chemmanur et al., 2011). A dynamic VC market affects the economy of countries. Innovation has a crucial role in improving economic growth, and entrepreneurial firms are leading this trend (Lerner & Tag, 2013). Today, one of the main reasons for increasing innovation in modern countries is developed infrastructure to spread the activity of such investors in those societies. On the other hand, competition is running high in all fields globally, which instigates innovation in many areas. In light of the VC's role in the promotion of innovation, conducting this research seems to be necessary.

Venture capital is a vital financing resource of risky and high potential companies (Howell, 2020). Nonetheless, what VCs do consists of a broader range of activities compared to traditional financial intermediaries such as banks. In addition, to provide ventures with financial supports, they play diverse roles to develop the supported firm into a professional firm (Hellmann & Puri, 2002).

VCs have proven their standing in the modern world as financial and nonfinancial supporters of newborn businesses, which usually have small and medium sizes. They back start-ups that need money and also support them by taking part in their managerial and decision-making positions in exchange for earning partial ownership of the company's equity. This presence in enterprises can result in the improvement of innovation (Karimkhani et al., 2018).

By carrying out this research, VCs will be well aware of effective factors on innovation improvement and focus on more important factors during their investment process. Knowing these factors and their ranks can also improve the return of investment and increase the efficiency of investment decisions that are made at VCs. Therefore, the research is after factors by which VCs can enhance the innovation of target firms, and then tries to prioritize them in terms of importance to fill the existing gap in this area. Therefore, this research aims to answer these questions: What are the most important factors affecting innovation promotion of investee companies? And how important is each of them?

Venture capital as a branch of finance is a new area in Iran that needs more attention and support from decision-makers to take a more significant part of financing responsibility in the country. The present research is the first study in this field that aims to identify and prioritize the most important factors affecting innovation promotion of investee companies using Fuzzy MADM methods in Iran. This research can be helpful for VCs decision-makers to increase the quality of their investment decisions.

2. Literature Review

2.1. Venture Capital and Innovation

Pérez-Luño et al. (2011) suggest that the life cycle of business models and products are shortened; therefore, a firm's ability to offer new options to the market is critical. In the last decade, the ability of companies to innovate has drawn much attention thanks to technology changes, decline of products' life cycle, and globalization of markets (Nordman & Tolstoy, 2014). The only way to survive and prosper in fiercely competitive markets is innovation (Rosenbusch et al., 2011). Creating a start-up in a market doesn't necessarily positively affect job creation and economic growth, because a new business needs to be innovative to affect

those fields and mere presence in a market doesn't secure those positive effects (Colombelli et al., 2016). Supporting innovative new businesses, which usually have small and medium size, leads to economic growth, but founders of such businesses are faced with some troubles in financing their ideas. Investment in small and medium-sized businesses is a challenging decision because of high risks and deep information asymmetries (Hall, 2005; Lerner, 1995; Lerner & Tag, 2013). VCs are experts at addressing these problems by connecting innovative entrepreneurs to investors (Lerner & Tag, 2013). VC is a suitable alternative for ventures faced with hardship in obtaining financial aids from traditional financial intermediaries (Manigart et al., 2002). As venture capital investment plays a substantial role in financing innovation in economies, governments can help develop venture capital. For instance, from the beginning of Covid-19, billions of dollars in Europe, North America, and other parts of the world have been injected to protect VC-backed companies against the economic fallout of the disease (Janeway et al., 2021).

Although financing from banks is very difficult for entrepreneurs, they are willing to bear more degrees of risk compared to what is acceptable for banks (Lerner & Tag, 2013). In the comparison between venture capitalists and banks in providing small and medium-sized enterprises with external financing, VCs support firms in a variety of aspects in addition to financial aids. They can play active and multi-faceted roles like strategic and operational conduct of their portfolio firms such as the employment of expert personnel, development of a business plan, creation of contact with other firms, clients and investors because they possess deep knowledge about the related industry (Hellmann & Puri, 2000). Banks are an indispensable source of financing the new firms, but compared to VCs in fulfilling the venture's financial needs, banks are more sluggish (Ueda, 2004).

VC development in a country is highly dependent on the development of the country's financial markets because the developed stock market prepares proper exit chances for VC firms (Lerner & Tag, 2013). A developed stock market affects innovation positively because the venture capital market under this circumstance is robust (Michelacci & Suarez, 2004).

Decision makers in organizations strive to make sure that not only their organization is innovative but also this innovation is persistent rather than temporary (Waldkirch et al., 2021). They improve the innovation of firms by investment in R&D activities (Hua et al., 2016). Spending on research and development activities promotes innovation, which can result in the commercialization of the idea (Lerner & Tag, 2013). They also may augment innovation by supporting firms to patent their inventions (Chemmanur et al., 2011; Conti et al., 2019; Hua et al., 2016; Lerner & Tag, 2013; Stuart et al., 1999). Gao (2007) suggests that VCs enhance innovation by facilitating firm's access to essential resources for growth and survival, increasing investment in R&D sector, setting the stage for next financings, establishing a motivational system for the investee firm, and highlighting the firm's goals to become a leading firm in the related industry. Chemmanur et al. (2011) suggest that VCs cooperate positively in fields such as providing a motivational atmosphere for both management and employees and connecting the venture to useful networks that include suppliers and potential customers. Hsu (2006) highlights the positive role of preceding alliances in order to start new partnership.

Lerner and Tag (2013) believe that innovative entrepreneurs face hardship in financing from banks because of asymmetric information and moral hazard. Dutta and Folta (2016) state that VCs increase innovation by playing some roles, which fall into three categories. These roles are useful to address problems like asymmetric information and moral hazard.

2.1.1. VC's Role as a Quality Signal and Information Intermediary

These investors enjoy in-depth relationships in the industry which provide precious contacts and information that are indispensable for early-stage ventures to prove their standing in the industry (Hellmann & Puri, 2000; Sorenson & Stuart, 2001). VCs may participate in innovation enhancement processes by supplying ventures with information about profitable cooperation with their fellow firms and preventing them from useless collaborating, which can adversely affect the venture's performance (Lindsey, 2008). Intermediaries like VCs can increase cooperation between firms through reducing transaction and search costs (Gans et al., 2000). VC investment in businesses sends a positive signal to the market about the bright future of that business, which results in increasing market visibility and reduces search costs to find potential partners. This positive signal to the market following the collaboration with a Venture Capitalist boosts venture's power to attract partners (Dutta & Folta, 2016) that leads to removing some obstacles for ventures to find a partner.

Higher search costs form the first challenge to find a partner. The next problem is that their quality is not yet discovered by the potential partners to assess their condition. The other impediment is that they are not well-developed to be a side of a partnership (Hsu, 2006). The endorsement can also be useful to attract human capital (Hellmann & Puri, 2000). The assimilation of competent employees is a significant challenge to convert a start-up into a mature organization (Hellmann & Puri, 2002). VCs also serve as an information go-between by providing outstanding information, which is critical to find proper resource partners. This access to resource partners enables ventures to create strategic alliances with their partners. These alliances, which form in the wake of VC investment, increase venture's innovation (Dutta & Folta, 2016). Firms usually see cooperation and the formation of relationships with other firms as a way to share their knowledge to promote their innovation performance (Wadhwa et al., 2016).

2.1.2. VC's Role in Governance

VCs seek to build a formal structure in the venture (Dutta & Folta, 2016) and create a system to monitor (Tekler et al., 2016) the firm actions through playing a governing role. Chemmanur et al. (2011) believe that monitoring by VCs boost the efficiency of the venture. VCs conduct them by signing substantial binding contracts (Ramón-Llorens & Hernandez-Canovas, 2013) and board members (Bernstein et al., 2016; Wen et al., 2018), which secure their right to be a part of decision-making process. Hellmann (1998) suggests that efficient contracts are critical to manage the conflict of interest. Sahlman (1990) emphasizes the role of the contracts between VCs and ventures in managing their relationship and identifying their rights and obligations. The contract should also reduce agency costs and operating costs to the lowest possible level.

They have business intelligence and valuable experience to provide the firm with precious mentorship that improves the venture's overall performance. They are eligible to take part in various business affairs to create value. VCs are well aware of the potential threats and opportunities that the venture faces and recognize them better than the founders of the business (Dutta & Folta, 2016).

2.1.3. VC's Role as a Financial Intermediary

VCs are investors who serve as a go-between and invest in high-risk private start-ups. They act as an intermediary between those who are willing to invest their money in high-risk

businesses with high potential growth and founders of those opportunities or ventures (Kortum & Lerner, 2001). VCs must create returns, so they care about the time horizon of investment and make great efforts to commercialize the invested idea and exit on time because VC is a time-oriented industry (Dutta & Folta, 2016). Gu and Qian (2019) suggest that VCs can support innovative firms and increase the likelihood of their prosperity through their rich experience and expertise in management.

Their obligations can decrease their tolerance toward some failures in adopting innovation because innovation doesn't come without spending. On the other hand, the successful adoption of innovation generates value. VCs incentives to exit within a stipulated time frame can result in taking a shorter time to reach the intended result, which is successful commercialization, shortening this process, and successful adoption of innovation (Dutta & Folta, 2016).

After an in-depth examination of the literature on VC, 18 factors affecting innovation of target firms from VCs perspective were extracted. These are presented in the following table.

Table 1. Factors Affecting Innovation of Target Firms

Row	Factors	References
1	Providing valuable information about the related industry	(Hellmann & Puri, 2000) (Sorenson & Stuart, 2001) (Lindsey, 2008) (Dutta & folta, 2016)
2	Having contact and cooperation with the industry activists	(Hellmann & Puri, 2000) (Sorenson & Stuart, 2001) (Lindsey, 2008) (Chemmanur et al., 2011)
3	Reducing search costs of potential partners	(Dutta & Folta, 2016)
4	reducing search costs of human capital	(Hellmann & Puri, 2000) (Stuart et al., 1999) (Lerner & Tag, 2013)
5	Supporting ventures to patent their inventions	(Chemmanur et al., 2011) (Hua et al., 2016) (Conti et al., 2019)
6	Facilitating the venture's access to essential resources for survival and growth	(Gao, 2007)
7	Establishing a formal structure	(Dutta & Folta, 2016)
8	Monitoring firm's actions	(Tekere et al., 2016) (Bernstein et al., 2016)
9	Signing obligatory and legal contracts	(Ramón-Llorens, & Hernández-Cánovas, 2013)
10	Informing the ventures about potential opportunities and threats	(Dutta & Folta, 2016)
11	Preventing ventures from entering harmful cooperation	(Lindsey, 2008)
12	Making great efforts to commercialize the idea	(Dutta & Folta, 2016) (Gu & Qian, 2019)
13	Trying to make an on-time exit	(Dutta & Folta, 2016)
14	Shortening the exit process	(Dutta & Folta, 2016) (Gao, 2007)
15	Increasing investment in R&D activities	(Lerner & Tag, 2013) (Hua et al., 2016)
16	Setting the stage for later financings	(Gao, 2007)
17	Creating a motivational system	(Gao, 2007) (Chemmanur et al., 2011)
18	Highlighting the firm's goals	(Gao, 2007)

3. Methodology

This paper sought to identify and then prioritize the most effective factors by which VCs increase the innovation of target firms. In order to answer research questions, the factors effective on the innovation of target firms from VCs perspective were extracted by studying literature. Initially, 18 effective factors on innovation were extracted that can be seen in Table 1. Then, by distributing questionnaire among 27 VC experts, their opinions about each factor's importance were gathered. In the next stage, by using statistical hypothesis testing, extracted factors were screened, and factors with less importance were removed. In the final step, the most critical factors were prioritized using 12 expert opinions through fuzzy DEMATEL method.

3.1. Statistical Hypothesis Testing

In the second step, we used statistical hypothesis testing to recognize the factors of consequence among 18 extracted factors and remove unimportant factors from the research. In order to conduct the second step, a five-point Likert-scale questionnaire was used. This was the first questionnaire of the research in which experts were asked to determine the importance of each 18 factors on innovation (1: very low, 2: low, 3: medium, 4: high, 5: very high) of target firms from VCs perspective. The questionnaire was filled out by 27 experts of the VC industry in Iran. After data collection, they were tested to see if they normally distributed using the Kolmogorov-Smirnov test. The result proved the existence of normal distribution in the data.

3.1.1. Test of Normality (Kolmogorov- Smirnov)

This test was conducted at 95 percent of confidence level; thus, the maximum acceptable level of error to reject the null hypothesis was 5 percent.

The hypotheses of the Kolmogorov-Smirnov test are as follows:

H_0 : The data come from the normal distribution.

H_1 : The data do not come from the normal distribution.

Table 2. Test of Normality

	Kolmogorov- Smirnov ^a		
	Statistic	df	Sig.
Total	.110	27	.200*

In the table above, the significant value shows the degree of committing an error in rejecting the null hypothesis, which is not acceptable here because it is more than 5 percent; therefore, the null hypothesis should be retained. The result shows that data is normally distributed. Thus, taking into account the hypotheses of the study, the one-sample t-test was applied as a parametric test.

3.1.2. One-Sample T-Test

In order to conduct the statistical hypothesis testing, one-sample t-test was used. This test was done at the confidence interval of 99%.

The hypotheses of the one-sample t-test are as below:

$$H_0 : \mu = 3$$

$$H_1 : \mu \neq 3$$

The statistic related to this test (t) is computed as follow:

$$t = \frac{\bar{x} - \mu_0}{s / \sqrt{n}} \quad (1)$$

where s is the standard deviation of the sample and n is the sample size.

Table 3. One-Sample T-Test

Factors	Test value= 3					
	T	df	Sig. (2-tailed)	Mean difference	99% confidence interval of the difference	
					Lower	Upper
Providing valuable information about the related industry	11.58	26	0	1.556	1.18	1.93
Having contact and cooperation with the industry activists	7.495	26	0	1.222	0.77	1.68
Reducing search costs of potential partners	1.551	26	0.133	0.296	-0.23	0.83
Reducing search costs of human capital	1.396	26	40.17	0.333	-0.33	1
Supporting ventures to patent their inventions	-2.74	26	0.011	-0.556	-1.12	0.01
Facilitating the venture's access to essential resources for survival and growth	6.671	26	0	1.037	0.61	1.47
Establishing a formal structure	-0.29	26	40.77	-0.074	-0.78	0.64
Monitoring firm's actions	2.401	26	0.024	0.519	-0.08	1.12
Signing obligatory and legal contracts	4.595	26	0	0.815	0.32	1.31
Informing the ventures about potential opportunities and threats	5.499	26	0	1.037	0.51	1.56
Preventing ventures from entering harmful cooperation	2.331	26	0.028	0.519	-0.1	1.14
Making great efforts to commercialize the idea	7.386	26	0	1.185	0.74	1.63
Trying to make an on-time exit	3.698	26	0.001	0.815	0.2	1.43
Shortening the exit process	7.495	26	0	1.222	0.77	1.68
Increasing investment in R&D activities	3.122	26	0.004	0.667	0.07	1.26
Setting the stage for later financings	5.573	26	0	0.963	0.48	1.44
Creating a motivational system	4.481	26	0	0.741	0.28	1.2
Highlighting the firm's goals	4.561	26	0	0.889	0.35	1.43

The highlighted factors on Table 3 were more important than average and entered the final step of the research, i.e., analysis through fuzzy DEMATEL method. The six factors with less importance removed from the research were reducing search costs of potential partners, reducing search costs of human capital, supporting ventures to patent their inventions, establishing a formal structure, monitoring firm's actions, and preventing ventures from entering harmful cooperation.

The most important VC-related factors to improve innovation of target firms, which were analyzed using fuzzy DEMATEL method were 1) providing valuable information about the related industry; 2) having contact and cooperation with the industry activists; 3) facilitating the venture's access to essential resources for survival and growth; 4) signing obligatory and legal contracts; 5) informing the ventures about potential opportunities and threats; 6) making great efforts to commercialize the idea; 7) trying to make an on-time exit; 8) shortening the exit process; 9) increasing investment in R&D activities; 10) setting the stage for later financings; 11) creating a motivational system; and 12) highlighting the firm's goals.

Therefore, by taking the second step, the 18 factors were screened and decreased into 12 factors that had more importance according to experts' opinions. Then, in the last step of the study, these 12 screened factors were prioritized using the questionnaire of fuzzy DEMATEL method, which was the second questionnaire of this research.

3.2. The Fuzzy DEMATEL Method

After recognizing the most important factors, they were prioritized in the final step of the research. To prioritize them, we used the fuzzy DEMATEL method.

DEMATEL method was first introduced by Memorial Institute. This method is well-known as a useful tool to determine the cause and effect relationships between specific criteria (Mehregan et al., 2012). The method is centered on the graph theory (Akyuz & Celik, 2015). This method is more useful than other techniques like Analytic Hierarchy Process (AHP) because it explains the interdependence between a group of factors by a causal diagram which is neglected in other techniques (Seker & Zavadskas, 2017). The combination of DEMATEL method with fuzzy sets, which is called fuzzy DEMATEL, is a beneficial method. Fuzzy DEMATEL method is useful to discover the relationships between factors and prioritize them according to the type of relationships and their strength in relation to each other. In fact, the chief advantage of fuzzy DEMATEL is to find relationships and determine their intensity in a fuzzy environment. The procedure of fuzzy DEMATEL method is presented as follow (Akyuz & Celik, 2015; Mentis et al., 2015; Seker & Zavadskas, 2017).

Step 1. The initial step is to define linguistic terms. To remove the uncertainty of human assessments, linguistic terms should be specified. In our study, experts chose the strength of every factor's effect on the other factors using some linguistic terms, namely no influence, very low influence, low influence, high influence, and very high influence. Hence, the different degrees of influence were expressed with five linguistic terms.

Table 4. Corresponding Relationships Between Linguistic Terms and Fuzzy Numbers (Yadegari & Tarokh, 2017)

Linguistic terms	Triangular fuzzy numbers
No influence	(1,1,1)
Very low influence	(2,3,4)
Low influence	(4,5,6)
High influence	(6,7,8)
Very high influence	(8,9,9)

Step 2. In this step, the decision makers were asked to determine the effect of each factor placed in every row, on every factor located on every column. Therefore, $\tilde{O}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ was the opinion of every expert about the effect of factor i on factor j . The effect of factor i on itself was zero (which means no influence); in other words, if $i = j$, the cell in the matrix is filled with zero, so the main diameter of the matrix is zero. For every expert, a $N \times N$ matrix with fuzzy numbers was defined as $\tilde{\sigma}^p = [\tilde{\sigma}_{ij}^p]$. N is the number of factors and P is the number of experts.

Step 3. After gathering all expert's opinions in the form of P matrixes, it was time to convert the P matrixes into one matrix, which is called initial direct relation by the simple average of the P matrices. The new matrix named initial direct relation might be shown as:

$$\tilde{O}_{ij} = \begin{bmatrix} \tilde{O}_{11} & \cdots & \tilde{O}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{O}_{m1} & \cdots & \tilde{O}_{mn} \end{bmatrix}, \tilde{O}_{ij} = \frac{1}{P} \times \sum_{P=1}^P \tilde{a}_{ij}^P \quad (2)$$

Step 4. The matrix of \tilde{O}_{ij} should be normalized by the following equations:

$$\tilde{Z}_h = 1/K \times \tilde{O}_h \quad h = l, m, u \quad (3)$$

$$k = \max_{1 \leq i \leq n} \left(\sum_{j=1}^n U_{ij} \right) \quad (4)$$

U_{ij} is the third element of each triangular fuzzy number.

$$\tilde{Z} = \begin{bmatrix} \tilde{Z}_{11} & \cdots & \tilde{Z}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{Z}_{m1} & \cdots & \tilde{Z}_{mn} \end{bmatrix} \quad (5)$$

Step 5. Since triangular fuzzy numbers were used in this study, every triplet fuzzy number in the normalized matrix should be split into 3 numbers to construct \tilde{Z}_l , \tilde{Z}_m , and \tilde{Z}_u . \tilde{Z}_l was made of the first numbers of every triplet fuzzy number, \tilde{Z}_m was made of the second number of every triplet fuzzy number, and \tilde{Z}_u was made of the third number of every triplet number in the normalized matrix. Then, three new matrixes were calculated according to the following equations:

$$l''_{ij} = \tilde{Z}_l \times (I - \tilde{Z}_l)^{-1} \quad (6)$$

$$m''_{ij} = \tilde{Z}_m \times (I - \tilde{Z}_m)^{-1} \quad (7)$$

$$u''_{ij} = \tilde{Z}_u \times (I - \tilde{Z}_u)^{-1} \quad (8)$$

In the next step, the three matrixes of l''_{ij} , m''_{ij} , and u''_{ij} had to be mixed in a new matrix called \tilde{V} , in which l''_{ij} , m''_{ij} , and u''_{ij} are respectively the first, second, and third element of every fuzzy number.

$$\tilde{V} = \begin{bmatrix} \tilde{V}_{11} & \cdots & \tilde{V}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{V}_{m1} & \cdots & \tilde{V}_{mn} \end{bmatrix} \quad (9)$$

Step 6. In this step, the defuzzification of fuzzy numbers of matrix \tilde{V} had to be conducted by the following formula:

$$V = \frac{(l + 4m + u)}{6} \quad (10)$$

Where l , m , and u are respectively the first, second, and third element of each fuzzy number. Therefore, the defuzzified matrix of V is as follows:

$$V = \begin{bmatrix} V_{11} & \dots & V_{1n} \\ \vdots & \ddots & \vdots \\ V_{m1} & \dots & V_{mn} \end{bmatrix} \tag{11}$$

Step 7. Calculating $(D_i + R_i)$ and $(D_i - R_i)$ was the next step. D_i is the overall effects of factor i on other factors which can be computed by summation of numbers in every row of matrix V in which the factor i is located. R_i is the overall effect that factor i has received from other factors, and can be calculated by the summation of numbers in every column of matrix V in which the factor i is located. $(D_i + R_i)$ can be defined as the overall influences that factor i both receives from and exerts on other factors. $(D_i - R_i)$ is the net effects that factor i receives from other factors.

4. Results

The questionnaire of fuzzy DEMATEL method was filled out by 12 experts of the VC industry in Iran. These 12 experts were among the 27 experts who took part in the first questionnaire. According to Asgharpour (2003), the size of expert panel for Fuzzy DEMATEL method can be 5 to 12. Each questionnaire was a 12×12 matrix because there were 12 factors. Thus, 12 matrices of 12×12 formed the collected data of this part. All steps of fuzzy DEMATEL method using gathered data are respectively as follow:

Table 5. Initial Direct Relations (Average)

Average	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12																								
F1	0.00	0.00	0.00	6.08	7.00	7.50	5.58	6.50	7.33	6.25	7.17	7.58	6.00	7.00	7.58	6.50	7.17	6.83	7.83	8.33	6.00	7.00	7.58	4.08	5.00	5.92	4.67	5.67	6.50	3.92	4.67	5.33	6.83	7.83	8.33	
F2	6.83	7.83	8.25	0.00	0.00	0.00	6.17	7.17	7.83	5.08	6.00	6.58	6.17	7.17	7.83	5.00	6.00	7.00	4.08	5.00	5.75	6.17	7.17	7.92	4.00	4.83	5.50	4.42	5.33	6.00	4.08	4.83	5.33	4.58	5.50	6.42
F3	3.08	4.00	4.92	4.17	5.00	5.75	0.00	0.00	0.00	3.67	4.50	5.33	4.42	5.33	6.25	5.83	6.83	7.58	3.25	4.17	5.00	5.50	6.50	7.17	4.25	5.17	6.00	4.75	5.50	6.08	3.67	4.50	5.25	4.25	5.17	6.08
F4	3.25	4.00	4.67	3.25	4.17	5.08	3.50	4.50	5.50	0.00	0.00	0.00	2.67	3.33	4.00	4.67	5.67	6.50	5.17	6.17	6.92	4.83	5.83	6.75	4.92	5.83	6.58	5.67	6.67	7.33	3.25	4.17	5.08	5.00	6.00	6.75
F5	3.75	4.67	5.50	4.08	5.00	5.83	4.00	4.83	5.50	4.58	5.50	6.33	0.00	0.00	0.00	5.33	6.33	7.17	5.83	6.83	7.50	4.42	5.33	6.25	5.08	6.00	6.75	4.25	5.17	6.08	4.25	5.17	6.08	6.67	7.67	8.08
F6	3.67	4.5	5.25	5.00	6.00	6.75	4.08	5.00	5.83	4.25	5.17	6.00	3.75	4.67	5.58	0.00	0.00	3.08	3.67	4.08	5.83	6.83	7.50	4.75	5.67	6.42	4.92	5.83	6.67	4.83	5.67	6.33	4.75	5.67	6.42	
F7	2.25	2.83	3.42	3.25	4.00	4.75	2.58	3.33	4.08	3.83	4.67	5.33	3.17	3.83	4.50	3.67	4.50	5.17	0.00	0.00	0.00	3.92	4.83	5.75	2.58	3.17	3.75	4.83	5.67	6.25	3.75	4.50	5.08	3.67	4.50	5.25
F8	2.83	3.50	4.17	3.67	4.50	5.33	4.08	4.83	5.42	4.75	5.67	6.42	4.08	5.00	5.83	6.33	7.33	7.92	5.08	6.00	6.67	0.00	0.00	0.00	4.25	5.17	6.00	5.25	6.17	6.83	4.75	5.67	6.33	5.33	6.17	6.75
F9	4.67	5.50	6.17	4.17	5.17	6.08	5.42	6.33	7.00	4.08	5.00	5.83	5.83	6.83	7.58	6.00	7.00	7.58	3.67	4.50	5.25	5.33	6.33	7.17	0.00	0.00	0.00	3.92	4.83	5.67	3.50	4.33	5.17	4.75	5.67	6.42
F10	3.08	3.83	4.5	4.25	5.17	6.00	5.17	6.00	6.50	5.33	6.33	7.08	3.92	4.67	5.25	5.67	6.67	7.33	4.67	5.50	6.08	5.00	5.83	6.42	5.50	6.50	7.25	0.00	0.00	0.00	4.75	5.50	6.08	4.58	5.50	6.25
F11	3.67	4.50	5.17	4.17	5.17	6.08	4.50	5.33	6.00	4.08	5.00	5.83	4.08	5.00	5.83	6.83	7.83	8.17	4.58	5.50	6.17	5.75	6.67	7.25	2.75	3.67	4.58	3.92	4.83	5.67	0.00	0.00	0.00	4.67	5.50	6.25
F12	4.67	5.67	6.50	6.00	7.00	7.75	5.00	6.00	6.83	4.42	5.33	6.08	4.67	5.67	6.50	6.00	7.00	7.75	3.83	4.83	5.83	5.50	6.50	7.33	5.17	6.17	7.08	4.33	5.33	6.25	5.33	6.33	7.17	0.00	0.00	0.00

Table 6 displays the average assessments of 12 experts, where linguistic terms are replaced by equivalent fuzzy numbers. F1 to F12 are exactly the factors in Table 4 with the same row number. The numbers of the above table are the average effects of each factor in rows on factors in columns.

Table 6. Normalized Initial Direct-Relation Fuzzy Matrix

Normalized	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12																									
F1	0.00	0.00	0.00	0.08	0.09	0.09	0.07	0.08	0.09	0.08	0.09	0.10	0.08	0.09	0.10	0.07	0.08	0.09	0.09	0.10	0.11	0.08	0.09	0.10	0.05	0.06	0.07	0.06	0.07	0.08	0.05	0.06	0.07	0.09	0.10	0.11	
F2	0.09	0.10	0.10	0.00	0.00	0.00	0.08	0.09	0.10	0.06	0.08	0.08	0.08	0.09	0.10	0.06	0.08	0.09	0.05	0.06	0.07	0.08	0.09	0.10	0.05	0.06	0.07	0.06	0.07	0.08	0.05	0.06	0.07	0.06	0.07	0.08	
F3	0.04	0.05	0.06	0.05	0.06	0.07	0.00	0.00	0.00	0.05	0.06	0.07	0.06	0.07	0.08	0.07	0.09	0.10	0.04	0.05	0.06	0.07	0.08	0.09	0.05	0.07	0.08	0.06	0.07	0.08	0.05	0.06	0.07	0.05	0.07	0.08	
F4	0.04	0.05	0.06	0.04	0.05	0.06	0.07	0.00	0.00	0.00	0.03	0.04	0.05	0.06	0.07	0.08	0.07	0.08	0.09	0.10	0.05	0.06	0.07	0.08	0.09	0.06	0.07	0.08	0.09	0.04	0.05	0.06	0.06	0.08	0.09		
F5	0.05	0.06	0.07	0.05	0.06	0.07	0.05	0.06	0.07	0.06	0.07	0.08	0.00	0.00	0.00	0.07	0.08	0.09	0.07	0.09	0.09	0.09	0.06	0.07	0.08	0.06	0.08	0.09	0.05	0.07	0.08	0.05	0.07	0.08	0.08	0.10	0.10
F6	0.05	0.06	0.07	0.06	0.08	0.09	0.05	0.06	0.07	0.05	0.07	0.08	0.05	0.06	0.07	0.00	0.00	0.00	0.04	0.05	0.05	0.07	0.09	0.09	0.06	0.07	0.08	0.06	0.07	0.08	0.06	0.07	0.08	0.06	0.07	0.08	
F7	0.03	0.04	0.04	0.04	0.05	0.06	0.03	0.04	0.05	0.05	0.06	0.07	0.04	0.05	0.06	0.05	0.06	0.07	0.00	0.00	0.00	0.05	0.06	0.07	0.03	0.04	0.05	0.06	0.07	0.08	0.05	0.06	0.06	0.05	0.06	0.07	
F8	0.04	0.04	0.05	0.05	0.06	0.07	0.05	0.06	0.07	0.06	0.07	0.08	0.05	0.06	0.07	0.08	0.09	0.10	0.06	0.08	0.08	0.00	0.00	0.00	0.05	0.07	0.08	0.07	0.08	0.09	0.06	0.07	0.08	0.07	0.08	0.09	
F9	0.06	0.07	0.08	0.05	0.07	0.08	0.07	0.08	0.09	0.05	0.06	0.07	0.07	0.08	0.09	0.10	0.05	0.06	0.07	0.07	0.08	0.09	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.07	0.04	0.05	0.07	0.06	0.07	0.08	
F10	0.04	0.05	0.06	0.05	0.07	0.08	0.07	0.08	0.08	0.07	0.08	0.09	0.05	0.06	0.07	0.07	0.08	0.09	0.06	0.07	0.08	0.06	0.07	0.08	0.07	0.08	0.09	0.00	0.00	0.00	0.06	0.07	0.08	0.06	0.07	0.08	
F11	0.05	0.06	0.07	0.05	0.07	0.08	0.06	0.07	0.08	0.05	0.06	0.07	0.05	0.06	0.07	0.09	0.10	0.10	0.06	0.07	0.08	0.07	0.08	0.09	0.03	0.05	0.06	0.05	0.06	0.07	0.00	0.00	0.00	0.06	0.07	0.08	
F12	0.06	0.07	0.08	0.08	0.09	0.10	0.06	0.08	0.09	0.06	0.07	0.08	0.06	0.07	0.08	0.08	0.09	0.10	0.05	0.06	0.07	0.07	0.08	0.09	0.07	0.08	0.09	0.05	0.07	0.08	0.07	0.08	0.09	0.00	0.00	0.00	

Table 7. Total Relation Fuzzy Matrix (\tilde{V})

\tilde{V}	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12																								
F1	0.10	0.21	0.46	0.18	0.32	0.61	0.18	0.32	0.62	0.19	0.33	0.62	0.18	0.32	0.61	0.20	0.36	0.70	0.19	0.33	0.62	0.20	0.36	0.69	0.16	0.29	0.59	0.17	0.32	0.62	0.15	0.28	0.56	0.21	0.35	0.66
F2	0.17	0.29	0.53	0.10	0.22	0.50	0.18	0.31	0.59	0.17	0.30	0.59	0.18	0.31	0.59	0.19	0.34	0.67	0.16	0.29	0.57	0.20	0.34	0.66	0.15	0.28	0.56	0.16	0.30	0.59	0.15	0.27	0.54	0.17	0.31	0.62
F3	0.11	0.22	0.45	0.14	0.25	0.51	0.09	0.19	0.45	0.13	0.25	0.51	0.14	0.25	0.51	0.18	0.31	0.61	0.13	0.24	0.50	0.17	0.30	0.59	0.14	0.25	0.51	0.15	0.26	0.53	0.13	0.24	0.48	0.15	0.27	0.55
F4	0.11	0.21	0.44	0.12	0.24	0.50	0.13	0.25	0.51	0.09	0.19	0.45	0.12	0.23	0.48	0.16	0.30	0.59	0.15	0.26	0.52	0.16	0.29	0.58	0.14	0.25	0.51	0.16	0.28	0.54	0.12	0.23	0.48	0.15	0.28	0.55
F5	0.13	0.24	0.48	0.14	0.27	0.54	0.15	0.27	0.55	0.15	0.28	0.56	0.10	0.21	0.47	0.18	0.33	0.64	0.17	0.29	0.56	0.17	0.31	0.62	0.15	0.28	0.55	0.15	0.28	0.56	0.14	0.26	0.53	0.19	0.32	0.61
F6	0.12	0.23	0.46	0.15	0.27	0.53	0.14	0.26	0.53	0.14	0.27	0.53	0.14	0.25	0.52	0.11	0.24	0.53	0.13	0.25	0.50	0.18	0.31	0.60	0.15	0.26	0.52	0.15	0.28	0.55	0.14	0.26	0.51	0.16	0.29	0.56
F7	0.09	0.17	0.36	0.11	0.20	0.42	0.10	0.20	0.42	0.12	0.22	0.43	0.11	0.20	0.41	0.13	0.24	0.49	0.07	0.16	0.36	0.13	0.24	0.48	0.10	0.19	0.41	0.13	0.23	0.45	0.11	0.20	0.41	0.12	0.23	0.45
F8	0.11	0.22	0.45	0.14	0.25	0.52	0.14	0.26	0.52	0.15	0.27	0.54	0.14	0.26	0.52	0.19	0.33	0.62	0.15	0.27	0.53	0.11	0.23	0.52	0.14	0.26	0.52	0.16	0.28	0.55	0.15	0.26	0.51	0.17	0.29	0.57
F9	0.14	0.25	0.49	0.14	0.27	0.54	0.16	0.29	0.56	0.15	0.27	0.55	0.16	0.29	0.56	0.19	0.33	0.64	0.14	0.26	0.53	0.18	0.32	0.62	0.09	0.20	0.47	0.15	0.27	0.55	0.13	0.25	0.51	0.16	0.30	0.58
F10	0.12	0.23	0.46	0.14	0.27	0.53	0.16	0.28	0.54	0.16	0.28	0.55	0.14	0.26	0.52	0.18	0.33	0.62	0.15	0.27	0.53	0.17	0.31	0.60	0.16	0.28	0.54	0.10	0.21	0.48	0.15	0.26	0.51	0.16	0.29	0.57
F11	0.12	0.23	0.46	0.14	0.26	0.52	0.15	0.26	0.52	0.14	0.26	0.53	0.14	0.26	0.52	0.19	0.33	0.62	0.15	0.27	0.52	0.17	0.31	0.60	0.12	0.24	0.50	0.14	0.26	0.53	0.09	0.19	0.43	0.16	0.28	0.56
F12	0.14	0.26	0.52	0.17	0.30	0.59	0.16	0.30	0.59	0.16	0.29	0.58	0.16	0.29	0.58	0.20	0.35	0.68	0.15	0.28	0.57	0.19	0.33	0.66	0.16	0.29	0.58	0.16	0.29	0.59	0.16	0.29	0.56	0.11	0.24	0.54

Table 8. Defuzzified Matrix of \tilde{V}

Real numbers	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
F1	0.24	0.36	0.36	0.37	0.36	0.41	0.37	0.40	0.33	0.36	0.44	1.58
F2	0.32	0.26	0.35	0.34	0.34	0.38	0.33	0.39	0.32	0.34	0.31	0.35
F3	0.25	0.29	0.23	0.29	0.29	0.35	0.28	0.34	0.29	0.30	0.27	0.31
F4	0.24	0.27	0.28	0.23	0.26	0.34	0.30	0.33	0.29	0.31	0.27	0.32
F5	0.27	0.31	0.31	0.32	0.25	0.37	0.33	0.35	0.31	0.32	0.30	0.36
F6	0.26	0.30	0.30	0.30	0.29	0.28	0.28	0.35	0.30	0.31	0.29	0.32
F7	0.20	0.23	0.23	0.25	0.23	0.28	0.19	0.27	0.22	0.26	0.23	0.26
F8	0.25	0.29	0.30	0.31	0.29	0.37	0.31	0.27	0.29	0.32	0.29	0.33
F9	0.28	0.31	0.32	0.31	0.32	0.37	0.30	0.36	0.24	0.31	0.29	0.33
F10	0.26	0.30	0.31	0.32	0.30	0.37	0.31	0.35	0.31	0.25	0.30	0.33
F11	0.26	0.29	0.30	0.30	0.29	0.37	0.30	0.35	0.28	0.30	0.22	0.32
F12	0.30	0.34	0.34	0.33	0.33	0.39	0.32	0.38	0.33	0.33	0.32	0.29

Table 9. Values of D_i , R_i , $D_i + R_i$ and $D_i - R_i$

D	R	D+R	D-R
F1	F12	5.1	2.45
F2	F6	4.28	0.48
F12	F8	4.14	0.25
F5	F10	3.71	0.23
F9	F4	3.67	0.05
F10	F3	3.63	0
F8	F7	3.62	-0.14
F6	F5	3.55	-0.23
F11	F2	3.55	-0.52
F3	F11	3.53	-0.7
F4	F9	3.51	-0.77
F7	F1	3.13	-1.1

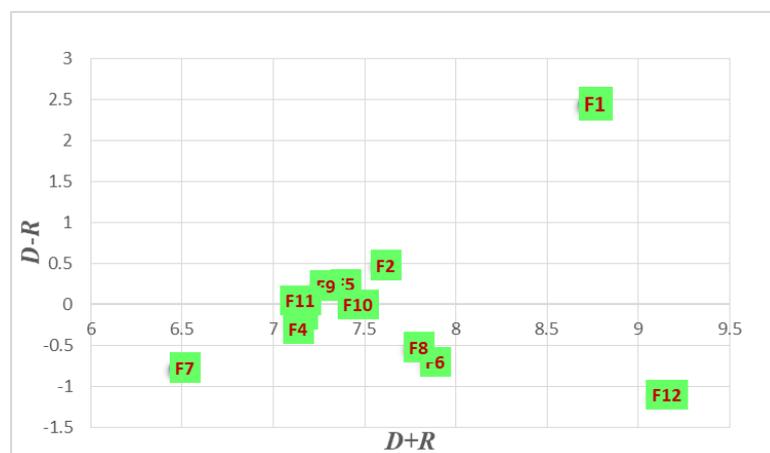


Figure 1. Causal Diagram Graph

According to Mehregan et al. (2012), the higher the $(D_i - R_i)$, the more importance has the factor. It means that a factor with higher net effect on other factors takes precedence over other factors. Therefore, the priority of factors in the order of importance is as follow:

Table 10. Priority of Factors

Priority	Factor	D-R
1	Providing valuable information about the related industry	2.45
2	Having contact and cooperation with the industry activists	0.48
3	Informing the ventures about potential opportunities and threats	0.25
4	Increasing investment in R&D activities	0.23
5	Creating a motivational system	0.05
6	Setting the stage for later financings	0
7	Facilitating the venture's access to essential resources for survival and growth	-0.14
8	Signing obligatory and legal contracts	-0.23
9	Shortening the exit process	-0.52
10	Making great efforts to commercialize the idea	-0.7
11	Trying to make an on-time exit	-0.77
12	Highlighting the firm's goals	-1.1

According to results, providing valuable information about the related industry, having contact and cooperation with the industry activists, informing the ventures about potential opportunities and threats, and increasing investment in R&D activities are respectively the most important and effective VC-related factors on the innovation of target firms. In other words, these factors are the most critical factors through which VCs improve the innovation of target firm. They exert the highest level of influence on other factors.

5. Discussion

On the one hand, innovation has become an outstanding feature of many prosperous businesses in the competitive world. On the other hand, VC investment may participate in innovation enhancement through some factors. Thus, this study aimed to identify and prioritize the most effective factors via which VCs enhance innovation of target firms. After a thorough examination of the literature, 18 factors effective on the innovation of investee firms were extracted. In the next step, by applying statistical hypothesis testing, these factors were screened and six factors with importance less than average were removed. Then, the remaining 12 factors entered the final step. In the last step, these 12 factors were prioritized by the fuzzy DEMATEL method based on the causal effects on each other. The results demonstrated that providing valuable information about the related industry (Dutta & Folta, 2016), having contact and cooperation with the industry activists (Dutta & Folta, 2016; Hellmann & Puri, 2002), informing the ventures about potential opportunities and threats (Dutta & Folta, 2016), and increasing investment in R&D activities (Gao, 2007; Hua et al., 2016) were the most important factors, because they had the most net effects on other factors. Focusing on the first three factors shows that a mutual characteristic is evident among them. The mutual quality is the vitality of the informational and relational network of VCs, which are integral to enhancing target firms' innovation. Thus, information has a crucial importance to boost innovation through VC investment and can also prevent some challenging problems. Information asymmetry is a major problem in venture capital firms, leading to agency problem and moral hazards (Glücksman, 2020). The results can also be viewed from the perspective of a developing market like Iran's financial markets. As mentioned earlier, asymmetric information between the two sides of an investment is a characteristic of the

Tehran Stock Exchange. Consequently, it is justifiable that factors that fill the informational gap in such markets become the most important factors. Therefore, venture capitalists have to spread their relational and informational networks. It involves investing in industries in which VCs are more competent and have in-depth knowledge about those industries rather than entering industries that are not well aware of their potential opportunities and threats. Hence, being familiar with the invested industry seems necessary; otherwise, VCs cannot provide ventures with valuable information and contact. The fourth factor is “increasing investment in R&D activities.” This factor has been chosen as one of the most important factors; in other words, one of the most influential factors that affect others. Since VCs have limited financial resources, increasing investment in a section may result in decreasing investment in other sections, but Tung and Binh (2021) argue that investment in R&D improves a firm’s revenue, profit, return on asset, and return on equity, which is entirely in line with VCs main purpose to invest. From another point of view, investment in the R&D sector is not only far from being a futile spending but also is a rewarding activity that may bear fruit in the future. It is precisely the thing that VCs are awaiting. Thus, increasing investments in R&D sector is justifiable even if it leads to decreasing investment in some other sectors.

Creating a motivational system is the fifth factor. This standing proves that all employees must be encouraged to do their best, and this is one of the main factors that can lead to innovation. Paying part of their annual salary by call options can be useful. This way, they will make a tremendous effort to play a positive role in increasing the enterprise’s shares. As enterprise shares leap in value until the expiry date of the options, the employees (as the owner of the options) will earn more profit. Therefore, a motivational organizational atmosphere is one in which the success of an organization equals its employees’ success. Setting the stage for the later financing is the sixth priority in experts’ estimations. The result of a VC investment sends meaningful signals to the market. If the investment produces favorable results, it indicates that the venture is a profitable opportunity for investment, but if it fails to provide the desirable profit, the market receives a negative signal about the indefinite future and potential of the venture; hence later financings may face troubles.

This research only examined the factors which are related to the VCs, but there are also other factors that are related to target firms which are crucial to improve their innovation. Therefore, a suitable suggestion for future studies is to examine the innovation issue of the target firms from the viewpoint of the investee firms. Another study that seems to be worthwhile is to investigate the effect of VCs on the productivity of target firms.

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