Investigating the Effect of Human Capital and Social Capital on Innovation Using the Fuzzy AHP Method

Ali Sasani[1], Motahareh Rabani[2], Amirhesam Behrooz[3]

[1] M.A. Candidate of Entrepreneurship Management, University of Tehran, Tehran, Iran
[2] M.S. Candidate of Industrial Engineering, University of Science and Culture, Iran
[3] M.S. Candidate of Executive Management of Business Administration, University of Tehran, Iran
E-mail: Ali_sasani@ut.ac.ir

Abstract: In this paper, we investigate the effects of two forms of capital, *i.e.* human capital at the specific-firm level and social capital at the organizational level on innovation. We use previous conceptualizations of human capital as educational levels and work experience and social capital as comprising trust, norms of civic behavior, and formal/informal networks to identify factors of human and social capital which affect on innovation. After that we prioritize them using Fuzzy analytic hierarchy process in Industrial Corporations of Tehran and Alborz provinces, during the period of 2010-2012.

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1. Introduction

There has been significant increase in the knowledge intensive side of economic activity at the global level. This has in turn increased academic and practitioners' interest in the various facets of knowledge creation and transfer within and between borders (Crosby, 2000). Knowledge is a valuable, rare, difficult to imitate and organization-specific resource (Barney, 1991; Kogut and Zander, 1996; Spender, 1996). Knowledge is critical to the process of innovation (Thornhill, 2006).

Prior researchers have examined how countries differ in terms of their level of innovative activity and have used Hofstede's (1980) cultural dimensions (i.e. uncertainty avoidance, individualism, power distance, and masculinity-femininity) to explain why certain countries innovate more than others (Dakhli and De Clercq, 2004). For instance, Shane (1992) found that individualistic and nonhierarchical societies are more inventive than other societies. Further, it has been suggested that societies that are more willing to accept uncertainty may be more innovative than uncertainty avoiding societies because the legitimacy of innovation championing roles is greater in corporations within the former societies (Shane, 1995).

In this paper, we focus on innovation as one of the most important aspects of knowledge creation (Collinson, 2000) and we explore the role of two forms of capital, i.e. human capital at the firm-specific level and social capital, as antecedents at the organizational level to innovative activity.

The human capital of a firm is defined as the knowledge and skills of its professionals that can be used to produce professional services (Pennings et al., 1998). Human capital theory distinguishes industry specific from firm-specific human capital (Becker, 1964). Firm-specific human capital is knowledge about unique routines and procedures that have limited value outside the firm in which the capital base has been developed (Pennings *et al.*, 1998). Professional degrees and industry experience, two indicators of industry-specific human capital, function as screening and filtering devices, because (1) people with high initial ability have good access to professional education (Arrow, 1973) and (2) less gifted people are more likely to be selected out during their early careers (Pennings *et al.*, 1998).

The term social capital was originally used to describe the relational resources, embedded in cross-cutting personal ties that are useful for the development of individuals in community social organizations (*e.g.*, Jacobs, 1961; Loury, 1977). Recent research has applied this concept to a broader range of social phenomena, including relations inside and outside the family (Coleman, 1988), relations within and beyond the firm (Burt, 1992), the organization-market interface (Baker, 1990), and public life in contemporary societies (Putnam, 1993, 1995). As several studies have pointed out, like physical and human capital, social capital is a productive resource, facilitating actions that range from an individual's occupational attainment (*e.g.*, Lin & Dumin, 1986; Lin, Ensel, & Vaughn, 1981; Marsden & Hurlbert, 1988) to a firm's business operations (*e.g.*, Baker, 1990; Burt, 1992; Coleman, 1990).

This study has considered identification and ranking factors of human and social capital which affect on innovation in Industrial Corporations in

Tehran and Alborz provinces, during the period of 2010-2012.

2. Literature Review

Innovation is a process that begins with an idea, proceeds with the development of an invention, and results in the introduction of a new product, process or service to the marketplace (Edwards and Gordon, 1984: 1). Innovative activity, which can be initiated by individuals or organizations, reflects a firm's entrepreneurial orientation (Lumpkin and Dess, 1996; Naman and Slevin, 1993). Innovation may be viewed as successful to the extent that it leads to a competitive advantage and consequent superior profitability (Roberts, 1999; Roberts and Amit, 2003).

Maskell and Malmberg (1999) argued that the overall stock of knowledge and skills in a society or region may enhance its overall competitiveness. Further, innovation, as a knowledge intensive activity, is expected to be related to human capital in multiple ways. Following the work of key commentators (Acs and Audrestch, 1990A, 1990B; Jaffe et al., 1993; Porter, 1990), innovation is regarded as the outcome of the interaction between human capital and knowledge spillovers, which creates cumulative learning effects (Faggian and McCann, 2009). Human capital refers to the value of knowledge, skills and experiences held by individual employees in a firm (McElroy, 2002). Human capital emanates from the fundamental assumption that human posse skills and abilities that can be improved, and as such can change the way people act (Becker, 1964). Human capital is necessary for the production of goods, services and knowledge *(*Teixeira and Fortuna, 2004). Its importance has increased as production processes become more knowledge intensive (de la Fuente, 2003a, 2004).Human capital is said to be embodied in the skills, knowledge, and expertise that people have; it has been seen as an important source of competitive advantage to individuals, organizations, and societies (Gimeno, Folta, Cooper, & Woo, 1997; Coleman, 1988). For example, Gimeno *et al*., (1997) found a positive association between the overall level of human capital, as measured by education level and work experience, and economic performance at both the entrepreneur's level and the firm's level.

Prior researchers have made a distinction between different types of human capital (Florin & Schultlze, 2000).

Firm-specific human capital pertains to skills and knowledge that are valuable only within a specific firm. For instance, prior researchers have examined the impact of firm-related know-how within the founding team on the success rate of high-growth start-up firms (*e.g*., Sandberg, 1986). Although firm-specific skills may give firms an advantage over their competitors as these skills are not transferable to other firms (Grant, 1996), the limited amount of communication and inter-firm reaction attached to those skills makes this type of human capital only have a limited impact on the level of innovative activity within a region or the wider society (Dakhli and De Clercq, 2004). Industry-specific human capital pertains to knowledge derived from experience specific to an industry, and several researchers have examined the role of industry experience on the growth and economic performance of entrepreneurial ventures (e.g. Siegel, Siegel, & MacMillan, 1993) as well as society (*e.g*., Kenney & von Burg, 1999). Prior research has suggested that industry-specific human capital may play an important role in the generation of innovative activity within an industry if it is characterized by high-quality knowledge exchange among the main players within that industry (*e.g*., Bianchi, 2001). Maskell and Malmberg (1999) argued that proximity in a 'cultural' sense within a region or industry matters in terms of innovation in that the exchange of tacit knowledge often requires a high degree of mutual understanding.

Individual-specific human capital refers to knowledge that is applicable to a broad range of firms and industries; it includes general managerial and entrepreneurial experience (*e.g*., Pennings, Lee, & van Witteloostuijn, 1998), the level of academic education and vocational training (*e.g*., Hinz, & Jungbauer-Gans, 1999), the individuals' age, and total household income (*e.g*., Kilkenny, Nalbarte, & Besser, 1999). Prior research has shown that one's overall level of human capital has an impact on economic success, both at the business level and the macro level. For instance, Kilkenny *et al*., (1999) discussed a human capital model for success and suggested that business success is positively related to one's level of training, overall business experience and total income.

Black and Lynch (1996) proposed that investment in human capital through on-the-job training and education are the driving force behind increases in productivity and competitiveness at the firm-specific level. (Dakhli and De Clercq, 2004).

Human capital will be developed through formal training and education aimed at updating and renewing one's capabilities in order to do well in society (Dakhli and De Clercq, 2004; Davidsson and Honig, 2003). Human capital is not only the result of formal education such as university education, but includes informal education, such as work experience and practical learning that takes place on the job, as well as non-formal education, such as specific training courses that are not a part of traditional formal educational structures and adult education (Davidsson and Honig, 2003). Thus, broad labor market experience, as well as specific vocationally oriented

experience, is theoretically predicted to increase human capital (Becker, 1964).

At the firm-specific level, this conversion process has been studied and validated by a number of researchers (*e.g*., Becker, 1964; Gradstein & Justman, 2000). In general, the argument is that those who are better educated, have more extensive work experience, and invest more time, energy, and resources in honing their skills are better able to secure higher benefits for themselves, and at the same time are better able to contribute to the overall well-being of the society (Dakhli and De Clercq, 2004). Theoretical models of human capital and economic growth are built around the hypotheses that knowledge and skills embodied in human capital directly raise productivity (Becker, 1962; Schultz, 1961) and increase an economy's ability to develop and to adopt new technologies (Nelson and Phelps, 1966). Ideas, innovations, opportunities, perspectives, and normative world-views are factors that may yield benefits for those individuals who live in environments that may be considered "discovery enriched" as a result of bridging social capital (Davidsson and Honig, 2003).

Social capital points to the value of relationships between people in firms, and between firms and other firms (McElroy, 2002). Social capital theory refers to the ability of actors to extract benefits from their social structures, networks, and memberships (Lin, Ensel and Vaughn, 1981; Portes, 1998). Social networks provided by extended family, community based, or organizational relationships are theorized to supplement the effects of education, experience, and financial capital (Bourdieu, 1983; Coleman, 1988; 1990; Loury, 1987). Social capital is multidimensional, and occurs at both the individual and the organizational levels (Nahapiet and Ghoshal, 1998). Social capital is broadly defined in the literature, among the various definitions and metaphors that occur in the literature, the following are the most relevant for defining the boundaries of the issue: (i) "a variety of different entities with two factors in common: they all consist of some aspects of social structure, and they facilitate certain actions – whether personal or corporate actors – within the structure" (Coleman, 1988); (ii) "those features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions" (Putnam, 1993); (iii) "a glue that holds societies together" (Serageldin, 1996).

Based on these definitions, social capital is possibly identifiable with the 'culture' of a group of agents, a culture of economic reciprocity and cooperation. Cainelli *et al*., (2007) argues that it is essential to move away from 'associative'-based concepts of social capital as presented in Robison *et al*., (2002) and Putnam (1993), and from analyses of trust and cooperation relying on 'honesty' treated as a sort of public good, toward frameworks in which social capital is conceived as an intangible capital stock with some public good-like properties, worthy of further investigation. Trust, reciprocity, shared values, networking, and norms are all things that, according to social capital theory, add value in a firm, or between firms, by speeding the transfer of information and the development of new knowledge (McElroy, 2002).

Social capital can take different forms, primarily trust, norms, and networks (Dasgupta and Serageldin, 2000; Fountain, 1998; Lesser, 2000; Putnam, 1993). Trust is developed over time through repeated series of interactions (Landry *et al*., 2002). Firms in milieu characterized by high levels of trust are more likely to innovative. Indeed, according to Knack and Keefer (1997): "Individuals in higher-trust societies spend less to protect themselves from being exploited in economic transactions. Written contracts are less likely to be needed, and they do not have to specify every possible contingency. Litigation may be less frequent. Individuals in high-trust societies are also likely to divert fewer resources to protecting themselves-through tax payments, bribes, or private security services and equipment- form unlawful (criminal) violations of their property rights. Low trust can also discourage innovation. If entrepreneurs must devote more time to monitoring possible malfeasance by partners, employees, and suppliers, they have less time to devote to innovation in new products or processes."

Norms of appropriate behavior also develop over time as a result of a series of interactions and exchange of resource (Landry *et al*., 2002). The norm that is the most often mentioned in the literature on social capital is reputation for trust-worthiness. Like for the case of trust, norms act as constraints on narrow self-interest, leading individuals to contribute productively to exchange instead of behaving opportunistically (Landry *et al*., 2002). Finally, networks develop as actors develop reliable and effective communication channels across organizational boundaries (Landry *et al*., 2002).

From an entrepreneurial perspective, social capital provides networks that facilitate the discovery of opportunities as well as the identification, collection, and allocation of scarce resources (Birley, 1985; Greene and Brown, 1997; Uzzi, 1999). Social capital also assists new firms by linking different organizations through weak ties (Davidsson and Honig, 2003). Informal networks may facilitate the establishment of new firms, through the use of multiple ownership, and the ensuing relationships they bring (Teach, Tarpley and Schwartz, 1986). Network "holes" provide advantages for organizations composed of individuals who span different networks

(Burt, 1980; 1992). Bridging social capital at the organizational level consists of collective relations such as organizational networks, engaging in interdependent activities utilizing a web of overlapping structures based on loosely coupled open systems (Burt, 1980; Galaskiewicz and Wasserman, 1993; Pfeffer and Salancik, 1978). These networks serve as conduits of information about innovation, the availability and character of markets, products, and resources (Davidsson and Honig, 2003).

Based on the arguments above, we propose the following structure:

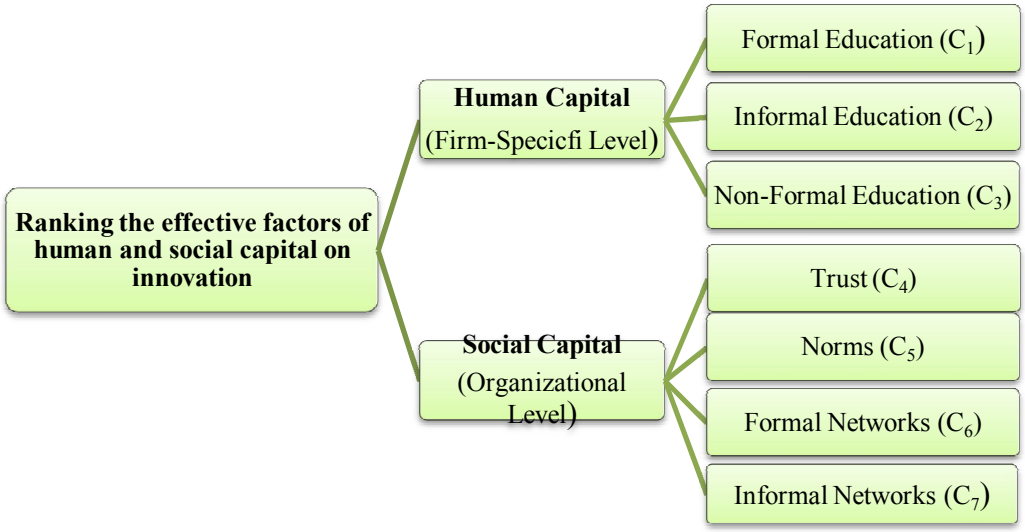

Fig 1. Conceptual Model

3. Methodology

The study began in April 2010 with exploratory discussions among a small group of academics and practitioners. Potential items were drawn from an extensive review of both the formal literature and the Internet as well as a search of other instruments being developed. A draft questionnaire was developed and pilot tested by students at the Faculties of Entrepreneurship and management of Tehran University. The final questionnaire included several items to tap each of the dimensions mentioned above, as well as others relating to three-levels of education, trust, norms, networks, and demographic information. All potential human and social capital items had been identified in the literature and/or had been suggested by participants in the initial discussions. Each of 35 human and social capital items was provided with a 4-point Likert-type response scale ranging from 1 (*no, not much* or *no, not at all*) to 4 (yes, *definitely* or *yes, frequently*). The full questionnaire used in this project is available on request. The rest of the paper is organized as follows: The following section presents a concise treatment of the basic concepts of fuzzy sets and fuzzy numbers. Section 3.2 presents the methodology of fuzzy analytic hierarchy process. The application of the proposed framework is addressed in Section 4. Finally, conclusion is provided in Section 5.

3.1. Fuzzy sets and fuzzy numbers

Fuzzy set theory, which was introduced by Zadeh (1965) to deal with problems in which a source of vagueness is involved, has been utilized for incorporating imprecise data into the decision framework. A fuzzy set $\tilde{A}$ can be defined mathematically by a membership function $\mu_{\tilde{A}}(X)$, which assigns each element x in the universe of discourse X a real number in the interval [0,1]. A triangular fuzzy number $\tilde{A}$ can be defined by a triplet (a, b, c) as illustrated in Fig 2.

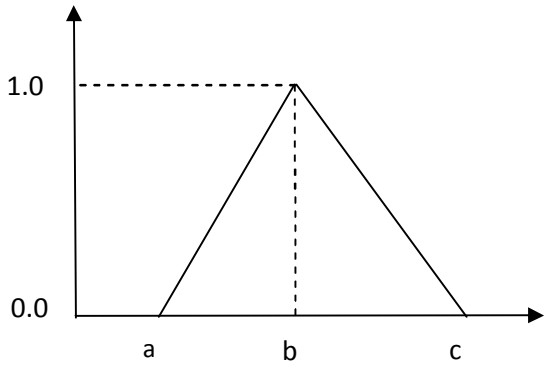

Fig 2. A triangular fuzzy number $\tilde{A}$

The membership function $\mu_{\tilde{A}}(X)$ is defined as

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-a}{b-a} & a \le x \le b \\ \frac{x-c}{b-c} & b \le x \le c \\ 0 & otherwise \end{cases} \quad (1)$$

Basic arithmetic operations on triangular fuzzy numbers $A_1 = (a_1,b_1,c_1)$, where $a_1 \le b_1 \le c_1$, and $A_2 = (a_2,b_2,c_2)$, where $a_2 \le b_2 \le c_2$, can be shown as follows:

Addition: $A_1 \oplus A_2 = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$ (2)

Subtraction: $A_1 \ominus A_2 = (a_1 - c_2, b_1 - b_2, c_1 - a_2)$ (3)

Multiplication: if k is a scalar

$$K \otimes A_1 = \begin{cases} (ka_1, kb_1, kc_1), & k > 0 \\ (kc_1, kb_1, ka_1), & k < 0 \end{cases}$$

$A_1 \otimes A_2 \approx (a_1a_2, b_1b_2, c_1c_2)$, if $a_1 \ge 0$, $a_2 \ge 0$ (4)

Division: $A_1 \oslash A_2 \approx \left(\frac{a_1}{c_2}, \frac{b_1}{b_2}, \frac{c_1}{a_2}\right)$, if $a_1 \ge 0$, $a_2 \ge 0$ (5)

Although multiplication and division operations on triangular fuzzy numbers do not necessarily yield a triangular fuzzy number, triangular fuzzy number approximations can be used for many practical applications (Kaufmann & Gupta, 1988). Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems including personnel selection (e.g. rating for creativity, personality, leadership, etc.). The primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation (Karsak, 2002). A linguistic variable is defined as a variable whose values are not numbers, but words or sentences in natural or artificial language. The concept of a linguistic variable appears as a useful means for providing approximate characterization of phenomena that are too complex or ill defined to be described in conventional quantitative terms (Zadeh, 1975).

3.2. Fuzzy AHP

Despite of its wide range of applications, the conventional AHP approach may not fully reflect a style of human thinking. One reason is that decision makers usually feel more confident to give interval judgments rather than expressing their judgments in the form of single numeric values. As a result, fuzzy AHP and its extensions are developed to solve alternative selection and justification problems. Although FAHP requires tedious computations, it is capable of capturing a human's appraisal of ambiguity when complex multi-attribute decision making problems are considered. In the literature, many FAHP methods have been proposed ever since the seminal paper by Van Laarhoven and Pedrycz (1983). In his earlier work, Saaty (1980) proposed a method to give meaning to both fuzziness in perception and fuzziness in meaning. This method measures the relativity of fuzziness by structuring the functions of a system hierarchically in a multiple attribute framework. Later on, Buckley (1985) extends Saaty's AHP method in which decision makers can express their preference using fuzzy ratios instead of crisp values. Chang (1996) developed a fuzzy extent analysis for AHP, which has similar steps as that of Saaty's crisp AHP. However, his approach is relatively easier in computation than the other fuzzy AHP approaches. In this paper, we make use of Chang's fuzzy extent analysis for AHP. Kahraman et al. (2003) applied Chang's (1996) fuzzy extent analysis in the selection of the best catering firm, facility layout and the best transportation company, respectively. Let $O = \{o_1,o_2, \ldots,o_n\}$ be an object set, and $U = \{g_1,g_2, \ldots,g_m\}$ be a goal set. According to the Chang's extent analysis, each object is considered one by one, and for each object, the analysis is carried out for each of the possible goals, g_i. Therefore, m extent analysis values for each object are obtained and shown as follows: $\tilde{M}_{g_i}^1, \tilde{M}_{g_i}^2, \ldots, \tilde{M}_{g_i}^m$, i=1, 2,…,n

Where $\tilde{M}_{g_i}^j$ (j=1,2,3,…, m) are all triangular fuzzy numbers. The membership function of the triangular fuzzy number is denoted by $M_{(x)}$. The steps of the Chang's extent analysis can be summarized as follows:

Step 1: The value of fuzzy synthetic extent with respect to the ith object is defined as:

$$S_i = \sum_{j=1}^{m} \tilde{M}_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{g_i}^j\right]^{-1} \quad (6)$$

Where $\otimes$ denotes the extended multiplication of two fuzzy numbers. In order to obtain $\sum_{j=1}^{m} \tilde{M}_{g_i}^j$

We perform the addition of m extent analysis values for a particular matrix such that,

$$\sum_{j=1}^{m} \tilde{M}_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \quad (7)$$

And to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{g_i}^j\right]^{-1}$ we perform the fuzzy addition operation of $\tilde{M}_{g_i}^j$ (j =1,2,…,m) values such that,

$$\sum_{i=1}^{n}\sum_{j=1}^{m}\tilde{M}_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i\ , \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \quad (8)$$

Then, the inverse of the vector is computed as,

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m}\tilde{M}_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}\ , \frac{1}{\sum_{i=1}^{n} m_i}\ , \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (9)$$

Where u_i , m_i , $l_i > 0$

Finally, to obtain the S_j, we perform the following multiplication:

$$S_i = \sum_{j=1}^{m}\tilde{M}_{g_i}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m}\tilde{M}_{g_i}^{j}\right]^{-1} =$$
$$\left(\sum_{j=1}^{m} l_j \otimes \sum_{i=1}^{n} l_i\ , \sum_{j=1}^{m} m_j \otimes \sum_{i=1}^{n} m_i, \sum_{j=1}^{m} u_j \otimes \sum_{i=1}^{n} u_i\right) \quad (10)$$

Step 2: The degree of possibility of $\tilde{M}_2 = (l_2 , m_2 , u_2) \geq \tilde{M}_1 = (l_1 , m_1 , u_1)$ is defined as

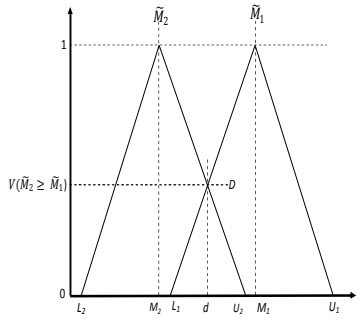

Fig 2.The degree of possibility of $\tilde{M}_1 \geq \tilde{M}_2$

$$V(\tilde{M}_2 \geq \tilde{M}_1) = sup[\min(\tilde{M}_1(x), \tilde{M}_2(y))] \quad (11)$$

This can be equivalently expressed as,

$$V(\tilde{M}_2 \geq \tilde{M}_1) = hgt(\tilde{M}_1 \cap \tilde{M}_2) =$$
$$\tilde{M}_2(d) = \begin{cases} 1 & if \quad m_2 \geq m_1 \\ 0 & if \quad l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \quad (12)$$

Fig. 2 illustrates $V(\tilde{M}_2 \geq \tilde{M}_1)$ for the case d for the case $m_1 < l_1 < u_2 < m_1$, where d is the abscissa value corresponding to the highest crossover point D between $\tilde{M}_1$ and $\tilde{M}_2$,To compare $\tilde{M}_1$ and $\tilde{M}_2$, we need both of the values $V(\tilde{M}_1 \geq \tilde{M}_2)$ and $V(\tilde{M}_2 \geq \tilde{M}_1)$.

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i(i=1, 2… K) is defined as

$$V(\tilde{M} \geq \tilde{M}_1, \tilde{M}_2, \ldots, \tilde{M}_k) = \min V(\tilde{M} \geq \tilde{M}_i), \quad i = 1,2,\ldots,k$$

Step 4: Finally, $W = (\min V(s_1 \geq s_k) \ \min V(s_2 \geq s_k), \ldots, \min V(s_n \geq s_k))^T$, is the weight vector for k = 1,…,n.

In order to perform a pairwise comparison among the parameters, we used the scale that is previously used in Ertuğrul et al (2008) paper. This scale is shown in Table 1.

Table 1. Linguistic variables for important of each criteria

linguistic variables	triangular fuzzy numbers
very low	(0.00,0.00,0.00)
low	(0.10,0.20,0.30)
medium low	(0.20,0.35,0.50)
medium	(0.40,0.50,0.60)
medium high	(0.50,0.65,0.80)
high	(0.70,0.80,0.90)
very high	(0.80,1.00,1.00)

4. The application of proposed approach

This study has been conducted for eight Industrial Corporations of Tehran and Alborz provinces. In this case, we want to prioritize effective factors on Innovation using the Fuzzy AHP. These factors are including: Formal Education (C_1), Informal Education (C_2), Non-Formal Education (C_3), Trust (C_4), Norms (C_5) Formal Networks (C_6) and Informal Networks (C_7). In Fuzzy AHP method, we determine the weights of each factor by utilizing pair-wise comparison matrixes. We compare each factor with respect to other factors. You can see the pair-wise comparison matrix for ranking of these factors in Table 2.

Table 2: Fuzzy pair-wise comparison matrix

	C_1	C_2	C_3	…	C_6	C_7
C_1	(1.00,1.00,1.00)	(0.33,0.50,1.00)	(0.33,0.50,1.00)	…	(0.33,0.50,1.00)	(1.00,2.00,3.00)
C_2	(1.00,2.00,3.00)	(1.00,1.00,1.00)	(3.00,4.00,5.00)	…	(1.00,2.00,3.00)	(4.00,5.00,6.00)
C_3	(1.00,2.00,3.00)	(0.20,0.25,0.33)	(1.00,1.00,1.00)	…	(1.00,2.00,3.00)	(3.00,4.00,5.00)
C_4	(0.25,0.33,0.50)	(0.33,0.50,1.00)	(0.20,0.25,0.33)	…	(0.25,0.33,0.50)	(1.00,2.00,3.00)
C_5	(0.33,0.50,1.00)	(0.25,0.33,0.50)	(0.25,0.33,0.50)	…	(1.00,1.00,2.00)	(0.33,0.50,1.00)
C_6	(1.00,2.00,3.00)	(0.33,0.50,1.00)	(0.33,0.50,1.00)	…	(1.00,1.00,1.00)	(2.00,3.00,4.00)
C_7	(0.33,0.50,1.00)	(0.17,0.20,0.25)	(0.20,0.25,0.33)	…	(0.25,0.33,0.50)	(1.00,1.00,1.00)

After forming fuzzy pair-wise comparison matrix, we calculate the weight of all criteria. The weight calculation details are given below. Because of the other calculations are similar for each comparison matrix, these are not given here and can be done simply according the computations below. The value of fuzzy synthetic extent with respect to the ith object (i = 1,2, . . . ,7) is calculated as

S_1= (6.00, 9.50, 14.00) ⊗ (0.02054, 0.01386, 0.00992) = (0.1232, 0.1317, 0.1389)
S_2= (13.00, 19.00, 25.00) ⊗ (0.02054, 0.01386, 0.00992) = (0.2670, 0.2634, 0.2481)
S_3= (11.20, 16.25, 21.33) ⊗ (0.02054, 0.01386, 0.00992) = (0.2300, 0.2253, 0.2117)
S_4= (4.03, 6.42, 9.33) ⊗ (0.02054, 0.01386, 0.00992) = (0.0828, 0.0889, 0.09263)
S_5= (3.50, 4.17, 7.00) ⊗ (0.02054, 0.01386, 0.00992) = (0.0718, 0.0577, 0.0694)
S_6= (7.67, 12.00, 17.00) ⊗ (0.02054, 0.01386, 0.00992) = (0.1574, 0.1663, 0.1687)
S_7= (3.28, 4.78, 7.08) ⊗ (0.02054, 0.01386, 0.00992) = (0.0674, 0.0663, 0.0703)

Then the V values calculated using these vectors are shown in Table 3.

Table 3. V values result

(V)	S_1	S_2	S_3	S_4	S_5	S_6	S_7
S_1		0.492962	0.493238	1	1	0.348242	1
S_2	1		1	1	1	1	1
S_3	1	0.591812		1	1	1	1
S_4	0.183319	0.499867	0.501948		1	0.455789	1
S_5	0.632801	0.489916	0.489374	0.299972		0.447567	0.312135
S_6	1	0.503154	0.509943	1	1		1
S_7	0.34599	0.499481	0.501177	0.356409	1	0.465566	

Thus, the weight vector from Table 3 is calculated and normalized as

W^t = (0.097948, 0.281264, 0.166455, 0.128197, 0.084371, 0.141519, 0.100245)

According to result of Fuzzy AHP, Informal Education (C_2) is the most important factor that effect on Innovation. Other factors ranked as follow: $C_2 > C_3 > C_6 > C_4 > C_7 > C_1 > C_5$.

5. Conclusion

Innovation is a process that begins with an idea, proceeds with the development of an invention, and results in the introduction of a new product, process or service to the marketplace (Edwards and Gordon, 1984: 1). Innovation is regarded as the outcome of the interaction between human capital and knowledge spillovers, which creates cumulative learning effects (Faggian and McCann, 2009). Human capital refers to the value of knowledge, skills and experiences held by individual employees in a firm (McElroy, 2002). Human capital emanates from the fundamental assumption that human posse skills and abilities that can be improved, and as such can change the way people act (Becker, 1964). Ideas, innovations, opportunities, perspectives, and normative world-views are factors that may yield benefits for those individuals who live in environments that may be considered "discovery enriched" as a result of bridging social capital (Davidsson and Honig, 2003). Social capital is an intermediate capital good, privately and intentionally produced, which endogenously accumulates from the flow of agents' investments in voluntary cooperative effort (Cainelli *et al*., 2007). Social capital is often operationalized through the identification of networks and network relationships, sometimes defined by the strength of ties, repetitive group activity such as the frequency of meetings and other formal interactions, as well as informal gatherings and other social activities, and social and family relationships (Davidsson and Honig , 2003). The main goal of this work was to investigate the effects of human capital at firm-specific level and social capital at organizational level on innovation using Fuzzy AHP method. The fuzzy AHP method evaluates factors and prioritizes them. According to fuzzy AHP result, Informal Education (C_2) is the most important factor that affect on innovation.

Corresponding Author:
Ali Sasani
M.S. Candidate of Entrepreneurship Management, University of Tehran, Tehran, Iran
E-mail: Ali_sasani@ut.ac.ir

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