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Research Article

Performance Evaluation of ICT Companies Using Hybrid MCDM Method in Iran

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The essential principles in sustainable development are information and communication technology and their influence on the country's economic progress. In essence, in culture, politics, economics, and society, information and communication technology are the driving force behind globalization. This has a significant impact on the emergence of the network society and cross-national awareness, and it is the primary driver behind global markets. A descriptive-analytical method is used in a scrolling manner, and a scientific approach is taken from the methodology's standpoint. ICT companies in a selected region of Iran were surveyed in a questionnaire survey. "Success" in ICT standard setting is discussed in this study. A fuzzy analytical hierarchy process (FAHP) and VIKOR methods were used to analyze data and prioritize the beneficial factors that contribute to the success of ICT companies. Twenty five ICT companies were evaluated using these methods. Utilizing the expert's opinion and previous research, 21 criteria into five categories were elicited and estimated near Tehran (Qom), Iran's capital. In this research, native influential factors are compared with other countries' general vital factors, which are distinct from previous studies. Based on the results, in-company management factors, technological and marketing factors, financial costs, government policies, and native features were the most important critical factors. As significant factors that influence the success of ICT companies, employee involvement, teamwork, customer focus, the state of the economy, and conflict of interest between governmental and private sectors were selected.

1. Introduction

The current entrepreneurial environment is characterized by ever-increasing competition, which is incited by globalization and the spread of free markets. Currently, there is an attempt to recuperate economies and enterprises from the global economic crisis. Increasing economic efficiency and reducing costs are essential for every business entity. It is more important than ever for the field of research, development, and innovation to develop new ideas. [1]. In addition to the effect of information and communication systems on economic growth, hope can be generated within the societies that develop this industry even with the limited resources and a large proportion of the population can use educational programs by being covered by this industry. In addition to the perpetuation of innovation, information and communication system can boost economic, commercial, and investment opportunities and finally lead to the welfare of citizens [2]. In the current world circumstance, there is a necessity for a better perception of world changes and selecting the policies in line with the active involvement in the information and communication community as a strategic option for the policymakers and planners of all countries. In this respect, studying the success factors of companies active in this field gains more importance and checking these factors and utilizing them can make a great

contribution to the countries' economic growth and increasing employment rate [3]. Information and communication technology is growing at a rapid pace in the world, especially in developing countries. For instance, according to the reported statistics by the international communication union in 2011 (2000–2010), the number of telephone lines per 100 people (as an ICT measuring indicator) has increased by 187%, 107%, and 255% for all the countries around the world, developed, and developing countries, respectively [4]. The number of Internet users per 100 people has also increased by 153%, 102%, and 235% for all the countries around the world, developed, and developing countries, respectively [5]. Between the years 2002 and 2010, the ratio of the families that had access to the Internet has been increased by 75%, 62%, and 123% for all the countries around the world, developed, and developing, countries, respectively. To study the success factors of the information and communication firms in this research, the experts in this field were interviewed while the literature was reviewed about the countries including Iran, South Korea, Malaysia, Portugal, Tunisia, Romania, and the USA to extract the critical success factor of companies in this field.

Firm ranking is a critical activity in the business community. Firms typically desire to know their relative position within their segment in order to implement the suitable strategy. Organizations in developed countries play this role. Generally speaking, there is no capital market in Iran to rank enterprises; instead, the Industrial Management Organization releases an annual list of the top hundred firms. Implementing an effective model that makes use of various factors is crucial due to the ranking's weaknesses. The MCDM model is used in the current study to evaluate Iranian ICT enterprises. This method was known as fuzzy AHP, which combines both logic and AHP approaches. The proposed strategy makes it simple to tackle the challenge of evaluating performance. In the VIKOR method, in order to rank and find the best alternative, it uses the concept of the worst alternative, and the degree of compromise between the distance of the options was compared to the best option, and for this reason, it is classified as a compromise planning method. Compared to the TOPSIS method, this method takes into account the importance of the optimal distance compared to the best case and the worst case in calculating the distances of the options. VIKOR and TOPSIS methods use different types of normalization to remove measurement units, while the VIKOR method uses linear normalization and the TOPSIS method uses vector normalization. The normalized value in the VIKOR method does not depend on the standard measurement unit, while the normalized values by the TOPSIS method may depend on the standard measurement unit. The VIKOR method prioritizes or ranks alternatives by evaluating options based on criteria. In the VIKOR technique, the criteria are not weighted, but the criteria are evaluated through other methods, and then, the alternatives are evaluated and ranked based on the criteria and by combining the values of the criteria. In this model, there are always several different alternatives, which are evaluated independently based on several criteria, and finally, the alternatives are ranked based on value. The main difference between the VIKOR technique and the AHP method is that, unlike those models, pairwise comparisons between criteria and options are not made in these models, and each option is independently measured and evaluated by a criterion. On the contrary, one of the weak points of the ELECTRE method is the use of the minimum threshold to calculate the effective coordination and inconsistency matrix. Therefore, the change in the amount of the threshold limit changes the answers of the problem to a large extent. Generally speaking, this method does not give us the complete and final ranking and is limited to presenting the best options.

The structure of this study is as follows: literature and the research history are done in Section 2, the research model and assumptions are done in Section 3, research methodology and the fuzzy method are discussed in Section 4, a numerical example and the province understudy are introduced in Section 5, research results are analyzed and compared with similar research studies in Section 6, and a conclusion is performed in Section 7.

2. Literature Review

Similar research studies about the success of ICT companies in countries such as Malaysia, South Korea, Romania, the Czech Republic, Sweden, Portugal, and the USA are studied in this section. Not only success factors of ICT companies have been studied in many of the research studies but also the relation between those factors and economic growth and efficiency of the countries have been surveyed. In some papers, internal factors of companies including managerial and technical factors have been studied too. In some other papers, external factors such as governmental policies, rules, regulation, and government confidence have been analyzed too [3]. Chong studied 11 success criteria for ICT companies in Malaysia based on knowledge management and stipulates that all these are effective on corporations' success with different values of effect. The criteria are the education of employees, involvement in activities, teamwork, empowerment of employees, top management leadership and commitment, employees' trust, information system infrastructure, performance measurement, benchmarking, and elimination of organizational constraints [6]. Marinescu et. al. have mentioned major financial criteria of net working capital, total asset, turnover, and total owner's equity as the four important and effective factors for the growth of the ICT firms in Romania. They have used mixed innovative econometrics to prioritize some strategies that will lead to the success of ICT firms [7]. Hong has performed a study similar to the previous study in South Korea and has pointed out that investment and ICT industry development in the private sector is more powerful in comparison to the public sector [8]. Igari conducted a comparative examination of Denmark and Japan, citing aspects such as the growth of user-oriented services, among others. Strong government initiatives (clear national strategies focusing on ICT usage/utilization and ICT-promoting mechanisms and policies), technologies that contribute to societal infrastructure (personal ID and digital signature systems), conflicts of

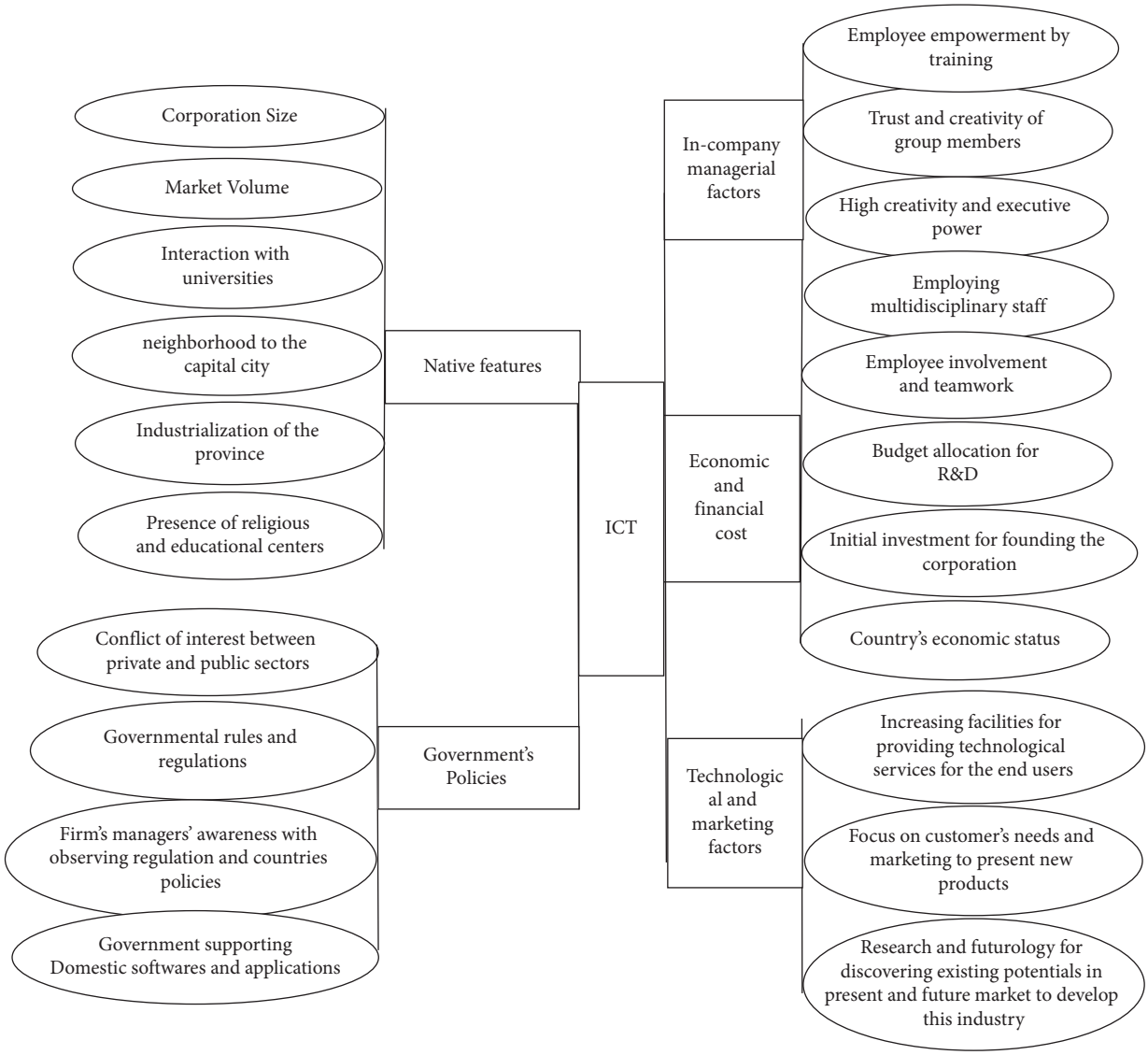

Figure 1: Research conceptual model.

interest between the private and public sectors, and firm founders' awareness of country regulations are important and effective factors for the development of the ICT industry in society among the people. Because of cultural, social, and political considerations, he has selected Denmark as the more successful country [9].

Alreemy et. al. have proposed five critical success factors in ICT including strategic alignment, environmental effects, organizational effects, executive management, and financial resources management. Analysis, futurology, and detection of existing potentials within the current and future market for ICT development are the important factors, which are studied in this research [10]. Jacobs has focused on the importance of teamwork and marketing development in different situations of ICT firms and found teamwork, attitude, and personal behavior of group members necessary for achieving success [9]. Njoh has studied connection between modern technologies of ICT and their development in African countries using linear regression. In this research, the effect of telephone, cell phone, Internet, wireless technology, etc., on development of this industry and its relation with economic growth of developing and developed countries has been studied [10]. Parka et al. had evaluated low costs, competiveness, social support, focus on services required by the customer, and marketing to present new products as the success factors in ICT [11]. Edquist and Henrekson have surveyed the effect of research and development units on ICT firm's performance in increasing Sweden's added value and economic growth [12]. Carnarella and Miller have introduced country's economic status, initial investment value, and corporation size as the effective factors of their research in the USA. By a nonlinear model, they have claimed that the growth of ICT firms is directly related to their size [13]. Finally, Zhang and Li have investigated local access to the Internet, telephone, cell phone, and their direct effect on private businesses [14]. Rouyendegh has employed B-FAHP and fuzzy TOPSIS to identify the best option among three competing farming methods

[15]. Based on the performed literature review, documents, and interviews with experts, effective factors for business development of information and communication technology corporations are extracted as seen in conceptual Figure 1. Five factors in form of managerial and internal factors, technological and marketing factors, financial and economic factors, governmental policies, and local indicators about the region under study (Qom) were studied as the main success factors for the ICT firms. According to the opinions and experience of the experts, 21 subcriteria in these five groups were identified, as shown in Figure 1.

Taghipour has used two different methodologies for selection of suppliers for speech recognition products in IT projects, IF-VIKOR, and q-ROF TOPSIS for speech recognition software supplier selection and then he compared these methods [16]. Moreover, Piya has shown us that the green score is calculated based on the integrated fuzzy AHP-TOPSIS method, which is an effective approach in MCDM [17]. Daneshvar Rouyendegh has tackled the process of efficiency measurement using multiattribute decision-making (MADM) processes where a sequential algorithm is proposed [18].

The process of efficiency measurement is tackled using multiattribute decision-making (MADM) processes where a sequential algorithm is proposed.

3. Research Model and Assumptions

The main goal of this research is to detect and prioritize effective criteria for success of information and communication technology company, categorizing and ranking them by utilizing the fuzzy AHP method. Main questions asked in this research are as follows:

What are criteria and subcriteria that are effective in the success of the ICT firms? What is the weight of each determined criteria? How is the prioritization of the success factors based on determined criteria? How is the executive model of quality level evaluation of the firms active in this field?

The main assumption is "there is a meaningful relationship between determined criteria in quality level evaluation of ICT's firms and the effective factors on their success." Hence, regarding the determined criteria and conceptual model, this research looks for determination of the relation between the criteria detected to be effective on the success of corporations in this field. Highlighting the effective factors on the success of the businesses related to information and communication technology especially for the people who tend to trigger these types of company is the main goal of this research. If the founders of the corporations know that consuming energy in which sections can take them closer to success and prevent dissipation, profusion and allocation of resources to the sections with lower levels of importance will have a significant role in sustainable success of the firms in the long term. From the point of view of the purpose, this research is classified as "applied" in the sense that we can discover the effective elements on the success of ICT enterprises by employing its findings. In this research, information was collected by the two methods of field study and library study. In the field study method, relation between the variables was detected by the experts' opinion. To collect information by library, methods such as reading different books on information and communication technology to find similar papers, studying multicriteria decision-making methods, and scrolling methods such as questionnaires, interviews, and using experts opinions were used and success factors were ranked using fuzzy AHP. This method has advantages such as a comprehensible unit pattern, procedure repetition, consensus and integration of judgments, interaction between factors forming options, combining the utility of options, analytical and systematic approach, noninsistence on linear thinking, hierarchical structure, and measuring nontangible items in the conduct and determination of priorities. To convert qualitative criteria to quantitative ones and couple comparison of each subcriterion with others, selected solutions can describe by two types of criteria, namely, quantitative criteria (such as price, income, and distance) and qualitative criteria (such as social image, hardness, security, and beauty). There are different methods to convert qualitative criteria to quantitative ones. One general method to measure qualitative criteria is interval scale (bipole interval scale) as described in Table 1.

Table 1: General method of measurement.

0.1	2, 3	4, 5	6, 7	8, 9
Very low	Low	Medium	High	Very high

This measurement is based on an eleven-point measurement, where zero has the least value and 10 has the most. This measurement is used for criteria with positive aspect and the more the desirability, the more the numerical value. It is necessary to note that the numbers 2, 4, 6, and 8 have the values between two values. In addition, 0 and 10 are the least used because they give absolute quantity to a variable. This type of measurement is done based on the assumption that the interval between two consecutive value (e.g., the interval between low and very low and the interval between high and very high) is equal. It is assumed that the score nine is triple as much as score three. Combination of values (addition, subtraction, multiplication, and division) is allowed for different values because the differences between two values are the same for each criterion. To determine the importance of each subcriterion in comparison to others, paired comparison questionnaire was created using the restorative method, and the importance of each criterion was determined in comparison to others based on the opinion of experts, university professors, and corporate executives. The tables with consistency higher than 0.1 were evaluated and checked again. Finally, numbers' consistency and final results of less than 0.1 were obtained. Research steps are shown in Figure 2.

The purpose of this study is to assess the performance of 18 ICT enterprises in a selected region of Iran (QOM). Consequently, each year the enterprise with the best performance is determined. To this end, an integrated method based on fuzzy AHP and VIKOR is presented for evaluating the performance of Iranian ICT companies. The first step for decision makers is to establish the relevant criteria with

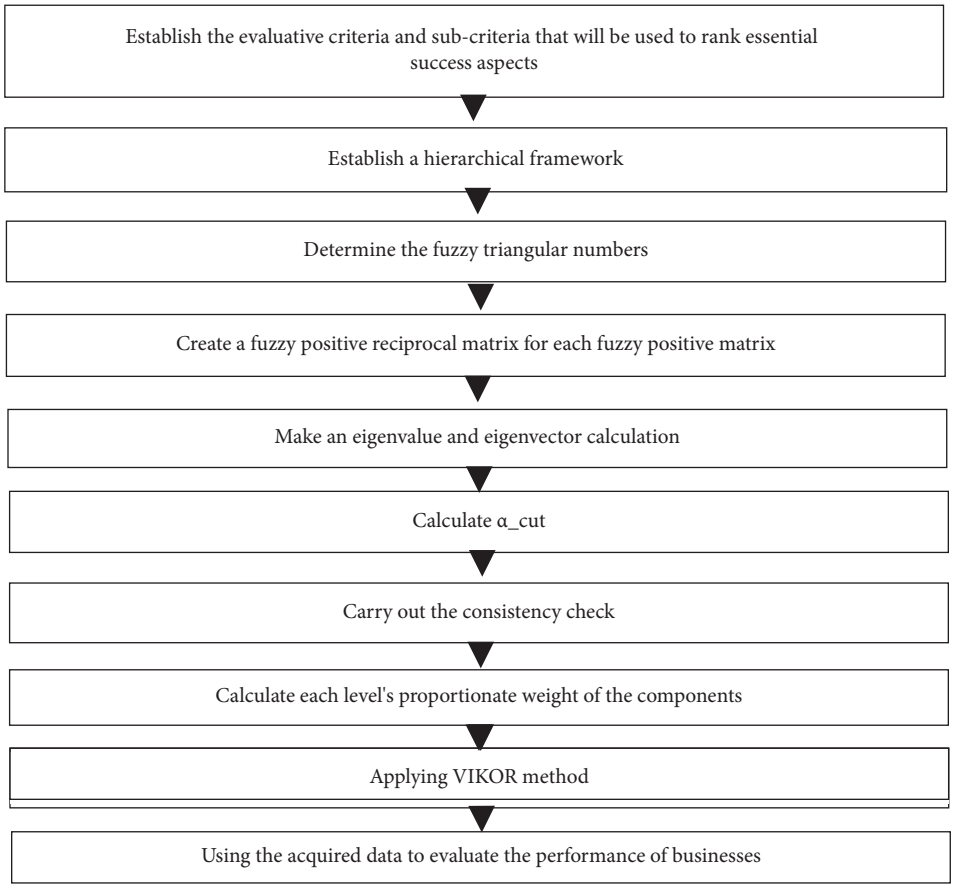

Figure 2: The proposed methodology.

which to evaluate the various ICT companies. The performance evaluation problem should be able to be described by the criteria and alternatives (Iranian ICT firms). The performance of Iranian ICT firms must be evaluated, so it is crucial that the evaluation committee carefully consider the abovementioned criteria. Determining the criteria and alternatives should be followed by setting up the problem as a hierarchical structure for decision makers. The complex decision-making problem that is currently in existence must be broken down into more manageable components at various levels by the hierarchical structure. The levels of the hierarchical structure can be determined by the chosen criteria. The target level addresses "evaluating the performance of Iranian ICT firms." Different criteria that have an impact on performance evaluation are addressed at Level 2 (the criteria level).

4. Research Methodology

In multicriteria decision-making issues, Saaty's AHP [19] solely employs the pairwise comparison matrix to analyze ambiguity. There is a condition in some problems that some experts are used to evaluate some options regarding the certain criteria or subcriteria to achieve a correct selection between the options and achieve the goal. The hierarchy analysis method that is described in this section was presented by Chang et al. [20]. To describe a specific decision situation completely, an AHP can have the same number of levels as expected. There are a number of practical attributes that make AHP a useful system. A decision maker needs to be capable of assessing subjective judgments, various decision makers, and the consistency of their inclinations in different situations [21]. We assume that each expert is asked to assess two criteria on a scale of one to ten in terms of the importance of the alternatives in contrast to one another and to choose the more significant option. This number is classic and does not have a fuzzy nature; hence, the paired comparison matrix is created in the form of

$$A = \left[a_{ij}\right] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix}. \quad (1)$$

We assume that there are n experts. As shown in equation (2). L, M, and U show the minimum possible, most likely, and the maximum possible value of a fuzzy number, respectively.

We assume that there are n experts and B_{ijk} is the judgment of the expert number k about the relative importance of two criteria. Equations (2) and (3) are used to establish fuzzy numbers as follows:

$$\begin{aligned} \tilde{u}_{ij} &= \left(L_{ij}, M_{ij}, U_{ij}\right), \\ L_{ij} &\le M_{ij} \le U_{ij}, \\ L_{ij}, & \\ M_{ij}, & \\ U_{ij} &\in \left[\frac{1}{9}, 1\right] \cup [1, 9], \end{aligned} \tag{2}$$

Dummy

$$\begin{aligned} L_{ij} &= \min\left(B_{ijk}\right), \\ M_{ij} &= n\sqrt{\prod_{k=1}^{n} B_{ijk}}, \\ U_{ij} &= \max\left(B_{ijk}\right). \end{aligned} \tag{3}$$

Now, paired comparison matrix is formed as equation (4). This matrix contains fuzzy numbers as expressed as follows:

$$\tilde{A} = \left[\tilde{a}_{ij}\right] = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \dfrac{1}{\tilde{a}_{12}} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \dfrac{1}{\tilde{a}_{1n}} & \dfrac{1}{\tilde{a}_{2n}} & \cdots & 1 \end{bmatrix}. \tag{4}$$

A^k is the fuzzy judgment matrix of expert k and a_{ij} is the fuzzy evaluation between criterion i and criterion j of expert number k which shows the relative importance of criteria C_i and C_j given by expert k.

So, the fuzzy number is related to the comparison between C_1 and C_2. The judgments of all experts are considered in calculation of this number. Fuzzy numbers are shown in form of intervals after the establishment of of paired comparison matrix using triangular fuzzy numbers or using the concept of α cut. If $\alpha = 0$, meanwhile, there will be the largest interval or the highest level of uncertainty. If $\alpha = 1$, the desired interval will be a number that shows the smallest level of uncertainty. In this method, if $\alpha = 1$, the fuzzy number will be a classic one that is the middle number of two triangular fuzzy numbers. As mentioned before, M_{ij} is the geometric mean of the expert about comparison of component i and component j. Now, we assume that $\alpha = 0$ and the relative fuzzy number will be calculated as $[l_{ij}, l_{ij}]$. To convert this interval to a classic number, λ can be viewed as the degree of a decision-maker's pessimism [22], which is calculated using the following formula:

$$\left(a_{ij}^{\alpha}\right)^{\lambda} = \left[\lambda l_{ij}^{\alpha} + (1-\lambda).u_{ij}^{\alpha}\right], \quad 0 \le \lambda \le 1,\ 0 \le \alpha \le 1. \tag{5}$$

Saaty [19] suggests a consistency test to verify conformity of the calculation results. To calculate consistency rate (CR), eigenvalue $\lambda_{\max}$ of the single pairwise comparison matrix should firstly be determined. After finding $\lambda_{\max}$ values of consistency index, (*C.I.*) and CR can be obtained as follows:

$$\text{Cons.lnd} = \frac{\lambda_{\max} - m}{m - 1}, \tag{6}$$

Dummy

$$\text{cons.Ratio} = \frac{\text{Cons.lnd}}{\text{RI}}. \tag{7}$$

If the relative matrix is $n = 3$, CR has to be less than 0.05, and if it was $n = 4$, CR must be less than 0.08, and generally speaking, if the matrix is $n > 5$, CR must be less than 0.1 in order to allow us to declare appropriate consistency for the matrix. After checking the matrix consistency, the weights must be calculated. To do so, the mean for each row (M_i) has to be extracted:

$$\left(A^{\alpha}\right)^{\lambda} = \left[\left(a_{ij}^{\alpha}\right)^{\lambda}\right] = \begin{matrix} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} 1 \\ \left(a_{21}^{\alpha}\right)^{\lambda} \\ \cdots \\ \left(a_{n1}^{\alpha}\right)^{\lambda} \\ \left(a_{12}^{\alpha}\right)^{\lambda} \\ 1 \\ \vdots \\ \left(a_{n1}^{\alpha}\right)^{\lambda} \\ \cdots \\ \cdots \\ \ddots \\ \cdots \\ \left(a_{1n}^{\alpha}\right)^{\lambda} \\ \left(a_{2n}^{\alpha}\right)^{\lambda} \\ \\ 1 \end{bmatrix} \begin{matrix} \\ M_1 \\ M_2 \\ \vdots \\ M_n \end{matrix}. \tag{8}$$

Dummy

$$M_i = n\sqrt{\prod_{j=1}^{n}\left(a_{ij}^{\alpha}\right)^{\lambda}},$$
$$S = \sum_{i=1}^{n} M_i. \tag{9}$$

As it is observed, the summation of M_i is called S and Equation (10) is used for calculation of the compared element *i*. Then, weight vector for paired comparison matrix is determined in Equation (11):

$$w_i = \frac{M_i}{S}, \tag{10}$$

Dummy

$$W = (w_1, w_2, \ldots, w_n). \tag{11}$$

4.1. VIKOR Method. The VIKOR approach was designed as a multiattribute decision-making method to tackle a discrete decision-making issue with noncommensurable (different units) and competing criteria, and it was introduced as one appropriate strategy to be used inside the MCDM problem (Opricovic and Tzeng [23] and Opricovic Tzeng [24]) This method was developed based on Lp-metric [25]:

$$L_{pi} = \left\{\sum_{j=1}^{n}\left[\frac{\left(f_j^* - f_{ij}\right)}{\left(f_j^* - f_j^-\right)}\right]^p\right\}^{1/p}, \quad 1 \leqslant p \leqslant \infty;\ i = 1, 2, \ldots, m. \tag{12}$$

The ranking metrics are composed of L1, I, and L_{∞}. The VIKOR technique is broken down into the following steps [26].

Step 1 : we calculate normalized quantities utilizing Equation (13).

Suppose there are *m* alternatives and *n* criteria:

$$f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{v} x_{ij}^2}}. \tag{13}$$

Step 2 : we find the best, f*, and worst, f –j, quantities for each criterion.

If we suppose the j^{th} function illustrates a benefit, afterwards, $f^*_{\text{j}} = \max\ \text{f}_{\text{i}}$ (or setting an aspired level) and $f^-_{\text{j}} = \min\ \text{f}_{\text{ij}}$ (or setting a tolerable level). On the contrary, if we suppose that the j^{th} function illustrates a cost/risk, so $f_j^* = \min f_{ij}$ (or setting an aspired level) and $f_j^- = \max f_{\text{ij}}$ (or setting the tolerable level).

Step 3 : we determine the relative importance of each of the criteria.

We compute the weights of the criteria to represent their relative importance. In this study fuzzy AHP was employed.

Step 4 : we compute the values Si and R_{i}, $i = 1,2,\ldots,\text{m}$, by the following equations:

$$S_i = \sum_{j=1}^{n} w_j \frac{\left(f_j^* - f_{ij}\right)}{\left(f_j^* - f_{ij}^-\right)},$$
$$R_i = \max\left[w_j \frac{\left(f_j^* - f_{ij}\right)}{\left(f_j^* - f_j^-\right)}\right], \tag{14}$$

where $w\,j$ are the weights of criteria, expressing their relative importance.

Step 5 : we compute the values Q_i, $i = 1, 2,\ldots,\text{m}$, by the following relation:

$$Q_i = v\frac{\left(S_i - S^*\right)}{\left(S^- - S^*\right)} + (1 - v)\frac{\left(R_i - R^*\right)}{\left(R^- - R^*\right)}, \tag{15}$$

where

$$S^* = \min_i S_i,$$
$$S^- = \max_i S_i,$$
$$R^* = \min_i R_i,$$
$$R^- = \max_i R_i. \tag{16}$$

Using V as the weight for "the majority of criteria" (or "the maximum group utility"), let us assume that it equals 0.5.

Step 6 : we sort the alternatives by values *S*, *R*, and *Q* in decreasing order and rank them. Three ranking lists emerge from the research.

Step 7 : if the following two conditions are met, we consider alternative A', which is ranked as the best alternative by the measure Q(Minimum), as a compromise solution.

First condition: acceptable advantage is given as follows:

$$Q(A'') - Q(A'') \geq \frac{1}{m - 1}, \tag{17}$$

where A'' is the alternative ranked second in the ranking list by *Q* and *m* is the number of alternatives.

Second condition: acceptable decision-making stability is that the alternative A'' must also be the best ranked by *S* or/and *R*. Within a process of decision-making, this compromise solution is stable. This compromise resolution is stable inside a decision-making process such as "vote by majority rule" (where $v > 0.5$ is required), "by consensus" (v 0.5), or "with veto" (v 0.5). The weight of the decision-making method "the majority of criteria" (or "the largest group utility") is v in this case.

A set of compromise solutions are suggested if one of the conditions is not met, and they are as follows:

If only condition 2 is not met, then alternatives A' and A'' are available oralternatives A', A'', $A^{(M)}$; if condition 2 is not satisfied, $A^{(M)}$ is determined by the relation $Q(A^{(M)}) - Q(A') < 1/m - 1$. For maximum *M*, the positions of these alternatives are "in closeness" [27, 28].

5. Information on the Information Technology Businesses in Qom

The fuzzy AHP method is now used to quantify the importance weight of the criteria that will be used in VIKOR after the criteria for evaluating the performance of Iranian cement firms have been established. Qom province includes one county and five cities. Information technology has no role in occupation and employment in this province (or equal to 0.1%, that is about 10 to 15 people in whole five cities). The total trade of this field of technology is related to the city of Qom, and it was formed after the year 1990 with the foundation of the Islamic sciences computer research center and was giving out lots of computers to the students of Islamic sciences to buy, sell, and establish software and content in Qom. About five institutes and shops were activated from 1990 to 1992 in hardware and software services. The establishment of more job opportunities was accelerated by the activities of these organizations and the investment of Islamic science centers. Regarding the importance of Qom province in information and communication technology, 21 subcriteria were identified in five critical criteria. Criteria and subcriteria importance comparisons were made by questionnaire. Answers to the questionnaire are inputs of the fuzzy AHP model. Fuzzy AHP combines the input comparison data and uses the mean answers to analyze the criteria. The normalization and calculation of weight vectors follow this approach. To establish paired comparison matrix, 45 questionnaires were distributed among the university professors, corporate managers, and their marketing managers and 34 questionnaires were filled and sent back by them. The weight of all criteria and subcriteria are calculated the same. To create paired comparison matrix from 34 questionnaire filled by senior experts of information and communication technology, all elements of the matrix were calculated using equation (5). This matrix is the same as matrix 4:

$$A = \begin{vmatrix} (1,1,1) & (0.11,1.53,8) & (0.11,1.34,8) & (0.11,0.85,9) & (0.25,2.26,9) \\ (0.125,0.64,9) & (1,1,1) & (0.14,1.86,8) & (0.11,0.95,6) & (0.2,292,8) \\ (0.12,0.73,9) & (0.12,1,7) & (1,1,1) & (0.12,1.76,9) & (0.12,1.73,9) \\ (0.11,1.15,9) & (0.16,1.16,9) & (0.11,1.25,6) & (1,1,1) & (0.12,1.12,9) \\ (0.11,1.15,4) & (0.12,1.076,5) & (0.11,1.15,8) & (0.14,0.63,8) & (1,1,1) \end{vmatrix}. \quad (18)$$

This matrix is then converted to interval fuzzy numbers using α_cut concept (α was assumed 0.5 in this example):

$$A = \begin{vmatrix} (1,1) & (0.82,4.76) & (0.72,4.67) & (0.48,4.92) & (1.25,5.63) \\ (0.34,4.82) & (1,1) & (1,493) & (0.53,3.47) & (2.74,5.46) \\ (0.42,4.86) & (0.56,4) & (1,1) & (0.94,5.38) & (0.92,5.36) \\ (0.63,5.075) & (0.61,5.08) & (0.68,3.62) & (1,1) & [0.06,2.06] \\ (0.58,2.52) & (0.6,3.03) & (0.63,4.57) & (0.38,4.3) & (1,1) \end{vmatrix}. \quad (19)$$

A p coefficient λ is defined in this stage regarding equation (5) to convert the matrix containing fuzzy information to a paired comparison matrix with classic numbers λ, which was assumed to be equal to 5 in this example:

Table 2: Weights of criteria and global priority.

Rank	Weight	Criteria
1	0.223	Managerial and internal factors
2	0.218	Technological and marketing factors
3	0.214	Financial costs
4	0.188	Government policies
5	0.156	Local features

$$\begin{aligned} 2.79 &= [4.76\,(0.5-1)+0.82*0.5], \\ 2.69 &= [4.67\,(0.5-1)+0.72*0.5]. \end{aligned} \tag{20}$$

All matrix elements are calculated the same to create matrix 6. The calculation result is as follows:

$$A = \left|a_{ij}\right| = \begin{vmatrix} 1 & 2.79 & 2.69 & 2.70 & 3.44 \\ 2.60 & 1 & 2.96 & 2.03 & 4.1 \\ 2.64 & 2.28 & 1 & 3.16 & 3.14 \\ 2.85 & 2.84 & 2.15 & 1 & 2.06 \\ 1.55 & 1.81 & 2.60 & 2.34 & 1 \end{vmatrix}. \tag{21}$$

CR = 0.135 and it has an acceptable consistency. Now, the weights of the criteria are calculated using the obtained paired comparison matrix from Equation (6):

$$\begin{aligned} \mathrm{M1} &= \frac{\sqrt{1*2.79*2.69*2.703.44}}{1} = 2.89, \\ \mathrm{w1} &= \frac{2.89}{12.95} = 0.223, \\ \mathrm{M2} &= \frac{\sqrt{2.60*1*2.96*2*4.1}}{1} = 2.81, \\ \mathrm{w2} &= \frac{2.81}{12.95} = 0.216, \\ \mathrm{M3} &= \frac{\sqrt{2.64*2.28*1*3.16*3.14}}{1} = 2.78, \\ \mathrm{w3} &= \frac{2.78}{12.95} = 0.214, \\ \mathrm{M4} &= \frac{\sqrt{2.85*2.84*2.15*1*2.06}}{1} = 2.44, \\ \mathrm{w4} &= \frac{2.44}{12.95} = 0.188, \\ \mathrm{M5} &= \frac{\sqrt{1.55*1.81*2.6*2.34*1}}{1} = 2.03, \\ \mathrm{w5} &= \frac{2.03}{12.95} = 0.156. \end{aligned} \tag{22}$$

Table (2) shows the weight of the criteria and the priority of the main factors, and Figure 3 represented the weights of the criteria and subcriteria:

$$W_c = (W_1, W_2, W_3, W_4, W_5) = (0.223, 0.216, 0.214, 0.188, 0.156). \tag{23}$$

5.1. Implementation of VIKOR. The VIKOR method evaluates ICT firms after the criteria weights have been determined. Special attention should be paid to the sizing of the companies ranked in the ICT industry [31]. Following this, the values of Si and Ri, which represent the distance with the best and worst solutions, are computed in Table (3) using Equations (12) and (13), respectively.

As can be seen in Table (4), VIKOR values are calculated for other alternatives.

Value of VIKOR for (FA) firm with V = 0.5 will be computed as follows:

$$Q1 = 0.5 \times \frac{0.7361 - 0.8435}{0.4100 - 0.8435} + (1 - 0.5) \times \frac{0.1479 - 0.1846}{0.1202 - 0.1846} = 0.404. \tag{24}$$

Similarly, the values of VIKOR are calculated for other alternatives and are shown in Table 5.

The best (F^*) and the worst (F−) values for all criteria are shown in Table (4). Similarly, the values of VIKOR are calculated for other ICT firms and are shown in Table (5)

The best rank can be provided as a compromise solution if acceptable advantages and stability are met. Because it was rated top in Si and Ri, FQ company was more significant than the average distance and met both the criterion of "accepted advantage" and "acceptable stability," as shown in Table (6). The weight of the "majority of characteristics" strategy has been introduced as the parameter v [30]. The value of V is assumed to be 0.5. It is vital to note that m has a significant impact on business rankings [23]. To validate the obtained results, a sensitivity analysis on v is performed in the interval [0,1]. Table 1 shows the consequences of varying the value of v (6). According to the results, FQ and FR are the best-ranked firms, and FJ and FK are the worst-ranked firms for all values of v.

There are differences in the ranking of ICT enterprises when v is modified. This investigation revealed that the recommended methodology's acquired findings are trustworthy.

6. Results' Analysis

The results of this research show factors that can be helpful in the success of the ICT firms if we invest in them. Focusing on internal organization management and establishing a cordial atmosphere among the employees to enhance teamwork and increase trust between them are the most basic and essential factors in the critical success of a company. As shown in Table 6, the confidence and creativity of the team members have the second rank among the critical factors which approve the result of the work done by Jo et al. [31]. In their research of Chong in Malaysia, he also pointed out organizational and internal factors as important factors

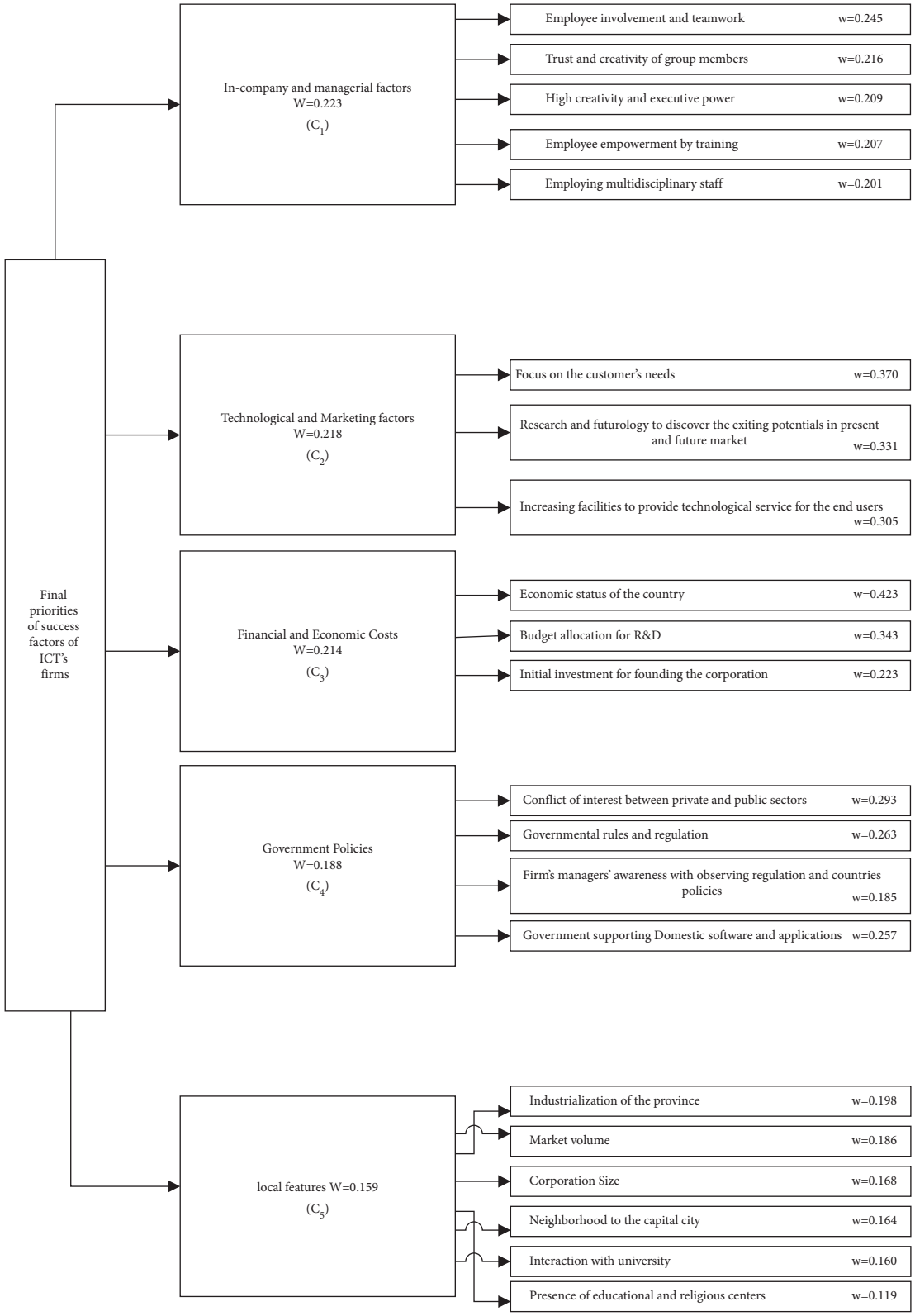

Figure 3: Final prioritizing of the criteria and subcriteria.

effective on the success of ICT firms [6]. Igari mentioned two factors, namely, managerial and internal factors and government policies, as the top critical success factors in his comparison study. Studying the results of this research shows that organizational factors and the inner potentials of a corporation have the leading role in its success. Broadly speaking, development from the technical, high financial income, and marketing aspect are the consequences of

Table 3: Values of S_i and R_i.

Alternatives	S_i	R_i
FA	0.7361	0.1479
FB	0.4951	0.1581
FC	0.5932	0.1778
FD	0.7648	0.1621
FE	0.5253	0.1235
FF	0.5742	0.1524
FG	0.4653	0.1275
FH	0.6792	0.1832
FI	0.6491	0.1553
FJ	0.6293	0.1846
FK	0.8435	0.1642
FL	0.6452	0.1702
FM	0.7276	0.1413
FN	0.6923	0.1623
FO	0.7373	0.1453
FP	0.7645	0.1632
FQ	0.4092	0.1412
FR	0.5212	0.1202

Table 4: Best and worst value of criteria.

	C_1					C_2			C_3			C_4				C_5			
	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{21}	C_{22}	C_{23}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{51}	C_{52}	C_{53}	C_{54}	C_{55}
F^*	2.91	1.88	0.41	0.18	0.52	0.81	0.32	5.23	0.87	0.76	1.23	5.21	1.34	0.64	0.94	1.66	0.67	0.87	1.23
$F-$	0.28	0.07	0.003	0.79	0.12	0.20	3.98	1.47	0.16	0.10	0.17	0.09	0.07	0.01	0.03	0.35	0.17	0.18	0.21

Table 5: VIKOR method result.

Alternatives	Q_j	Rank
FA	0.406	11
FB	0.227	5
FC	0.409	10
FD	0.491	15
FE	0.141	4
FF	0.283	6
FG	0.089	2
FH	0.495	16
FI	0.310	7
FJ	0.463	14
FK	0.583	18
FL	0.421	12
FM	0.379	8
FN	0.437	13
FO	0.397	9
FP	0.498	17
FQ	0.084	1
FR	0.103	3

Table 6: Firms are ranked according to their V values.

V = 0	V = 0.25	V = 0.5	V = 0.75	V = 1
FR	FR	FQ	FQ	FQ
FE	FG	FG	FG	FG
FG	FE	FR	FR	FB
FM	FQ	FE	FE	FR
FQ	FB	FB	FB	FE
FO	FF	FF	FF	FF
FA	FI	FI	FI	FC
FI	FM	FM	FC	FI
FF	FO	FO	FL	FJ
FB	FA	FC	FJ	FL
FD	FN	FA	FN	FH
FP	FD	FL	FM	FN
FN	FL	FN	FH	FM
FK	FP	FJ	FO	FA
FL	FC	FD	FA	FO
FC	FK	FH	FD	FP
FH	FH	FP	FP	FD
FJ	FJ	FK	FK	FK

correct organization and management of a corporation and its employees that, if focused, can be helpful for the business. A country's economic status acts as the suitable infrastructure for activities of the corporations that are on top of financial and economic factors. Canarella and Miller [13] stated the USA economic recession in 2007 as a factor of benefit reduction of the ICT firms and mentioned the country's economic status as the most effective success factor of the corporations. Furthermore, the corporation's technical development and provision of better services is attention to the research and development unit and allocation of proper budget to it. Next to this factor, increasing a firm's technical capability in line with suitable marketing for service provision in this field will lead to the growth of corporations' business environment and dynamic of the corporation. Edquist and Henrekson [12] also mention the founding and performance development of this unit within the corporation as one of the main preconditions of founding the firms. General status of the country's economy and attention to performing researches to achieve more

technical knowledge and initial investment are also the next factors of growth and development of corporations. One of the differences of this research with others is covering most of the important criteria that are important in success of companies. In most research studies, managerial factors, financial costs, and governmental policies are studied separately. Considering these factors all together can provide more suitable overview for prioritizing the criteria. Results of this research proved that selected policy for facilitating business environment is the fourth effective factor on ICT firms. Conflicts of interest between private and public sectors, approved laws of this field, government supporting domestic products, and managers' awareness of the rules of business environment are the subset factors of government's policies. For example, Igari conflicts of interest between private and public sectors with governmental rules are on the top of factors related to the government's policy about success of these companies. However, an important achievement of this research is the evaluation of role and position of native features and characteristics in development of business environment in ICT that is well shown and has lower role and position in comparison to four other factors. In this study, it is worth to point out that a factor that has been especially focused on is native features that are not found in other research studies. Results of this research clearly show that success in this field is largely independent of geographical and local factors. Despite important characteristics such as neighborhood to the capital city and presence of religious centers, these factors have low ranks among the factors effective on the success of an ICT's firms. Generally speaking, managerial factors and organizing the company, high technical capability for provision of new products, and services and powerful marketing are the most growth factors of a corporation active in the field of information and communication technology. The most significant subcriteria among the primary elements are employee engagement and collaboration; we focus on customer demands, country's economic position, conflicts of interest between private and governmental sectors, and the province's industrialization. In other words, internal variables such as government policies, rules, and natural characteristics are more essential than exterior elements such as government policies, rules, and native features. It is necessary for ICT business managers and founders to evaluate and prioritize these criteria in order to achieve success.

7. Conclusion

Information and communication technology points to the technology that facilitates remote access to information. It is a technology that is correlated with human life. Information technology includes processes such as production, processing, saving, data recovery, transfer, and rate. In addition, it consists of elements such as software, hardware, computer systems designers, producers, electronic components, and computer device suppliers. Innovation and creativity caused change or improvement of these elements. Technology has caused workforce development in the society, innovation development global education infrastructure change, and improvement of human and mechanical connections throughout the world. Hence, research on the success factors of the active corporations in this field gains importance. The study presents the phases of development and application of multicriteria decision-making models. The definition of criteria of importance for selection of the most efficient ICT firm's using the hybrid MCDM method was performed. Utilizing an integrated fuzzy AHP–VIKOR method and the FMCDM method, 21 factors across five categories were evaluated and prioritized based on literature review and interviews. In the case of ICT companies, the investigation and evaluation of their performance can be simplified by using the FMCDM method. Results showed that managerial and interorganization factors have the most important roles in the success of ICT firms. Economy, financial costs, and technological factors are in the next levels. The influence of the components on each other may be examined using ANP in the future, and comparing various additional MCDM approaches such as SAW, TOPSIS, ELECTRE, PROMETHEE, and ORESTE in a fuzzy environment can be used to prioritize the criteria, with the results being compared. Examining the impact of local characteristics in various parts of the nation can provide similar conclusions. Additionally, the proposed method can be applied to assess other segments [34–36].

Data Availability

All the data used to support the findings of the study can be obtained from the corresponding authors upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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