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Application of Fuzzy Analytical Network Process (ANP) and VIKOR for the Assessment of Green Agility Critical Success Factors in Dairy Companies

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Abstract: Manufacturing companies are facing rapid and unanticipated changes in their business environment. Most of these companies need to find new strategies to remain competitive in the market. Therefore, the main purpose of this study is to integrate the Fuzzy Analytical Network Process (ANP) and VIKOR methods to evaluate the green agile factors and sub-factors in the dairy companies in Iran. To find the green agile factors and sub-factors, this study used the expert's opinions and literature review. Data is collected from four dairy companies. The results of this study showed that the most important green agility factors are: trust-based relationship with suppliers, flexible production capacity, versatile workers, compliance with quality standards for a new product, and workers' willingness to learn. In addition, the results indicated that the green agility organization is one of the strategies that help companies to stay in the market. To validate the results, this study used four methods, including TOPSIS, ARAS, EDAS, and MABAC. The necessity of a reaction to the increasing customer choices, environmental concerns, and competitiveness among manufacturers across the globe has engaged the industry to embrace innovative manufacturing strategies.

Keywords: Supply Chain Management; Multi-Criteria Decision-Making; Green Supplier; Sustainability

1. Introduction

In recent years, firms have been obliged to make changes to their business process because of market transformations and technology innovations. Cost, quality, timeliness, and even flexibility are progressively becoming order qualifiers, hence pushing firms to devise businesses gravitating around innovativeness, responsibility, and customer intimacy [1]. Golpîra et al. [2] believe that it is important for companies to obtain a balance between economic interests and environmental protection, especially because of altered consumers' behavior toward green products and services.

Lee et al. [3] reported that green business accepts the environmental principles and respects the environment, which improves the quality of life for customers and protects existing resources. Green business operations involve reducing, reusing, recycling, reworking, returning, and remanufacturing [4]. Green marketing is focused on developing and marketing the products and services that can satisfy the customers' needs while taking environmental sustainability into account [5]. In addition, firms can focus on developing new and clean products. If products are overpriced or produced with lower quality or fail to consider the environmental benefits, the customers will not be attracted to them, and this will affect the firm's overall performance [6].

In recent years, environmental management issues have become more and more important to both public and private organizations [7]. Improvement of image, profitability, levels of emissions or customer satisfaction are several reasons for organizations to further consider environmental issues. The companies need to minimize adverse environmental impacts and waste of resources and raw materials during the procedure from the very beginning to the final stage and disposal of products [3]. Jovanović et al. [8] reported that organizations are in need of continuous change and development and require the implementation of various strategies. Agility is the normal evolution of flexibility over time which can help modern business organizations to remain in the competitive markets [9].

Implementation of agile methods can help companies to tailor the services and products to dynamic markets [10]. An agile organization is not only compatible with the business environment and ready for these anticipated changes but also qualified enough to sense the changes and respond to them in a quick and effective manner [11]. Nowadays, agility is a necessity for ensuring a competitive advantage and surviving. Customers demand the best products at a better price, less time, more customized, and in the desired value. This brings some problems for companies attempting to increase their market share. These companies are encountering a dynamic and unpredictable environment. Thus, agility and agility assessment of systems have been recognized as a necessary step for competing in a highly turbulent environment. Agile methods can help firms to have the best reaction to these challenges [12].

Agile manufacturing environment should be implemented in a consistent and systematic manner. Agile companies must be innovative, highly responsive, constantly experimenting in order to improve existing products and processes, and striving for less variability and greater capability [13]. Manufacturing practices for managing agility include enterprise integration, shared database, multimedia information network, product and process modeling, intelligent process control, virtual factory, design automation, super-computing, product data standards, paperless transactions via Electronic Data Interchange (EDI), high-speed information highway, etc. [14]. Ip et al. [15] suggested that the order of introduction of agility on shop floor should be adopting cellular layout followed by the reduction in a number of setups, paying attention to integrated quality, preventive maintenance, production control, inventory control, and finally improving relations with suppliers.

One of the goals of agile manufacturing is to produce customized products in a short time at low cost [16]. Another goal of all agile methods is to deliver products quickly and to adapt to changes in the process, product, and environment [17]. Jayatilleke and Lia [18] suggest that a wide variety of organizational settings have accepted the agile methods. Some methods are suitable for certain organizational environments while for a smaller organization, agile development is suitable.

Agile development designs new business models to enhance competitiveness and urges the need for a new organization model [19]. To win the competition in the global manufacturing environment, cooperation and collaboration among enterprises have played a key role in recent years [9]. Some factors affecting the environmental concerns include reduced response time to the customers, need to reach world-class score-cards, and coexistence with international competitors. These are the crucial factors in regards to the market needs [20].

Despite all these benefits, dairy companies all over the world suffered a dramatic decline in sale during the last decades. Iran, as the biggest dairy producer in the Middle East, producing 1.5 million tons of milk per year [21], is not an exception. The selected companies for this study (i.e., Kaleh, Haraz, Gela, and Saleh) are located in the same province (Mazandaran) and play an important role in the dairy market in Iran. They deliver their products to all parts of the country and also export them to countries, such as Afghanistan, Iraq, etc. These four companies employ several methods to introduce their products to the market, but nowadays they face problems to respond to the customers' demand and attract them to their brands. These companies produce a variety of dairy products and distribute them in a competitive market. Thus, these companies need to identify factors, metrics, and measures of green agility in order to satisfy the demands of the market. Many researchers [22,23] have discussed certain green production practices, such as green manufacturing, raw material reduction, and environmental design. Through the process of green production, the quality and variety of products must be taken into consideration [24]. The previous research has discussed the factors that can improve the green agility in the companies. However, there is a lack of research regarding the investigation of these factors in Iranian dairy companies. Therefore, the current study tries to fill this gap by identifying the key factors and sub-factors and providing a method for their measurement. Moreover, a comparative analysis of the green agility levels of these companies is provided.

2. Literature Review

The main factors determined in the previous studies are investigated in this paper. They are divided into five main categories: Market and customer agility, Technology agility, Production agility, Management agility, and Workforce agility.

2.1. The Market and Customer

Aravindraj and Vinodh [25] refer to this factor as an agile manufacturing capability. The customers' demand is increasing; thus, complex and dynamic actions are required to give appropriate services to customers. They expect to receive the products within a shorter period. Manufacturing organizations are attempting to be agile to produce a variety of products within a short period in a cost-effective manner. Heinonen and Strandvik [26] noted that providers see customers as targets to be activated and controlled, and the main concern for manufacturers is to differentiate themselves from their direct competitors. Peng et al. [27] believe that customers' behavior is changing. These dramatic changes to the fundamental characteristics of markets and business environments have precipitated an interest in creating new models for organizations. Based on researchers' opinion, markets need green agile products that can support the customers' demand. Customers pay attention to products that are perfectly suited to the environment.

2.2. Technology

Ji Sun et al. [28] noted that in such a dynamic environment, companies face increasing competition, including severe competence gaps, which presents a fundamental threat to their competitiveness and mere existence. In general, technology appropriation is greatly dependent upon and shaped by the surrounding environment, including social and economic forces beyond managerial intent. Matikiti et al. [29] believe that considering the social nature of technology and environment—when technology implies the relationship between social actors, and environment represents opportunities and constraints that can potentially promote or thwart an individual's goal attainments—we can understand that there is an interaction between technology and environment in reality. This is because how individuals use appropriate technology for their own goals is dependent on whether or not other social actors can create opportunities and/or remove constraints [27].

Mergel et al. [30] found that agile software development approaches involve creating, testing, and improving technology products incrementally in short, iterative sprints. The goal is to increase response to changes or mistakes discovered in the development processes. The overall project is broken down into small modules and short sprint cycles. Many of these agile principles have also made it into the agile development manifesto. Developing the technology approach also involves creating, testing, and improving technology products incrementally in short, iterative sprints. Based on Hausman and Johnston research [31], to gain a competitive advantage, it is crucial to develop innovations and technologies during the recession period. The literature on innovation notes that firms' innovative capacity depends greatly on external competitive pressures. Dai et al. [32] believe that to compete and succeed in stable markets, there is a need for different resources and innovative strategies. The high-tech entrepreneurial ventures have responded to the economic crisis through investments in product innovation and expansion into international markets. However, low-tech industries have to face additional difficulties in managing R&D projects during a crisis, as they require greater internal organizational capabilities to fit to rapidly changing external environments. It is important to have innovation activities in the long term to endure competitive pressures. In addition, firms need to develop strong internal capabilities to support their strategic objectives and survive during economic downturn conditions [33]. To answer the customers' demand, it is important to have facilities that can help us produce the products as soon as possible.

2.3. Production

Aqlan et al. [34] noted that dynamic changes in market demands and companies' strategies require the flexible introduction of new products and implementation of continuous improvement to internal processes in order to cope with the changes. One of the improving changes is consolidating production lines, especially when demand decreases and companies' strategies change.

Hasan et al. [35] believe that the traditional production layout is facing challenges as the product demands become smaller and shorter in lead-times. Lead times, set up times, work in process, quality, machine utilization, and employee job satisfaction are related to the production agility. Agile manufacturing is focused on these factors based on customers' demand [36]. According to emerging economy firms' (EEFs) opinion, to update the ideas about suppliers and move towards producing low-cost products, companies should focus on process development in a way to improve the products through moving from the state of mere imitation to innovation. They have gained momentum in many industries and have competed with developed firms not only within their own emerging markets but also within more developed ones. Successful EEFs are growing faster than their counterparts from developed markets and have been identified as global challenges [37]. This factor, which plays an important role in agile paradigms, affects key issues, such as modeling, producing, and delivering the products to customers.

2.4. Management

Famiyeh et al. [38] believe that Environment Management Practice (EMP) is a tool for an organization to manage the impacts of its activities on the environment. It provides a structured approach to planning and implementing environmental protection measures. EMP monitors environmental performance similar to the way a financial management system monitors expenditure and income, which enables an organization to regularly check its financial performance. Additionally, EMP integrates environmental management into a company's daily operations, long-term planning, and other quality management systems. Rathi [39] found that EMP is also one of the tools an organization can use to implement environmental policy. It illustrates an extension of the core principles of total quality programs to manage the environment. In other words, EMP can be described as the systematic application of business management to environmental issues [40]. It is important to understand the organizations' adoption behavior and identify the determinants of innovation by distinguishing the types of innovation. As adopting EMP involves implementing new or modified processes, techniques or systems to reduce environment damages, the adoption behavior can be considered as a technical innovation process [40].

Agile innovation management describes a set of project management and software development processes, adjusted procurement procedures combined with HR policies and organizational and managerial approaches in a way to support innovative digital service delivery in government. Innovation in government software development happens using an agile software development approach adopted from the private sector [30]. The firm's structure affects the firm's conduct, hence influencing its performance. Originally, most researchers took the approach of studying the structure of the industry and its direct links with the performance achieved [41]. It is important to test how political connections affect accounting quality, as stakeholders rely on corporate disclosure to improve their decision-making quality [42]. Managers make the decision about the company's strategy and can integrate agility into their decision-making processes.

2.5. Workforce

Agility of the workforce is broader than its flexibility, and it addresses a more strategic level. Workforce agility adds issues, such as motivation, attitude, behavior, and abilities, to human factors [43]. The Pitafi et al. [44] indicated that the agility shows an employee's ability of percipience and capability of responding to external changes, which requires the acquisition, interpretation, and utilization of relevant information. These information-processing procedures have an influence on employees in the workplace. Agility of employees reflects their ability to deal with environmental uncertainty through sensing and responding to external changes [45]. To build such agility, employees need to have sufficient sources of information and capabilities for processing such information. Specifically, agility contains the component of promptly sensing external changes, which requires employees to acquire a variety of information from multiple resources [44]. The workforce is one of the organizational parts in manufacturing without which no product can be produced. Therefore, this factor plays a key role in any company. Literature consists of studies conducted to find out agile factors. Table 1 shows the relevant factors and drivers.

Table 1. A review of research on the green agile factors.

Factors	Name of Sub-Factors	Reference
Market and customer	Matching customer feedback with products	Elgammal et al. [46]
	Flexible business	Ravichandran [47]
	Customer satisfaction rate of new product	Mourtzis et al. [48]
	Fast production and introducing the new product on time	Pinna et al., Morgan et al., Lo et al. [49–51]
	Respond quickly to competitors	Dikert et al. [52]
Technology	Diversity of equipment, technology, and operational workstations	Meneses et al. [53]
	Level of company's information excellence	Zraková et al. [54]
	Integration of technology and information	Zraková et al. [54]
	Network and information utilization rate for employees	Ravichandran [47]
	Applying the new communication media	Carr et al. [55]
Production	Modular design	Elgammal et al. [46]
	Flexible production capacity	Ravichandran, Chan et al., Queiroz et al. [47,56,57]
	Relationship based on trust with suppliers	Elgammal et al., Ravichandran [46,47]
	Decreasing non-added value costs	Rungi and Del Prete [58]
	Focusing on the costs of the system and identifying the activities that can add value	Rasnacis and Berzisa [59]
	To invest in the latest techniques, models, and design method	França et al. [60]
	Fixed manufacturing costs based on customer product pricing	Liu et al. [61]
	Short production development cycle	Paschek et al., Bondar et al. [62,63]
	Material transfer speed	Elgammal et al. [46]
	Creativity in products	Ravichandran [47]
	Product quality throughout the product longevity	Elgammal et al., Rasnacis and Berzisa [46,59]
	Resource optimization	Elgammal et al. [46]
	Cope with the change	Klein and Reinhart [64]
	Regarding quality standards in the production of new products	He and Yu [65]
Management	Hierarchy organizational chart beds	Pitafi et al. [43]
	Delegating management	Garwood and Poole [66]
	Management's interest in full automation	Karpinsky et al., Mossalam and Arafa [67,68]
	Management's interest in delivering new models	Mossalam and Arafa [69]
	Promoting a culture of transformation and modernization	Khoshlahn and Ardabili [70]
Workforce	New and existing employees' enthusiasm toward learning and training	Rathi et al. [38]
	Teamwork	Rasnacis and Berzisa, Hilt et al. [59,71]
	Institutionalizing staff design proposals	Zan et al. [72]
	Multi-skilled and flexible staff	Elgammal et al. [46]
	Collaboration interface	Valipour Khatir et al. [73]
	Creativity	Aqlan et al. [33]

3. Methods and Data

Data collection is important in any research since data leads to information. The more complete the information, the more correct and error-free results will be obtained. For this reason, the information about the factors and sub-factors are all collected from credible sources. Figure 1 shows the process of methodology. The research model is developed based on 21 experts' opinions. To collect the data from the selected companies, three separate questionnaires were prepared and filled by the participating specialists of the companies to detect the degree of factors' importance. The first questionnaire was used to determine the sub-factors. The experts then ranked the sub-factors from one to nine (lowest to highest importance), as shown in Table 2. 17 sub-factors from 35 sub-factors were finally selected and assessed. In the second questionnaire, paired comparisons were made between factors and sub-factors since the research was to compare fuzzy criteria. Nine-hour fuzzy spectrum was used that was preferably the same, interstitial, less preferred, in between, very little, intermediate, very high priority, and very little in between. In the third questionnaire, the companies were evaluated based on the green agility and ranked by VIKOR. A spectrum of seven language variables, such as very weak, weak, weak to moderate, moderate, relatively good, good, and very good, was used for the evaluation of factors and sub-factors within the company. Tables 2 and 3 show the equivalent fuzzy numbers, while Table 4 shows the experts' opinions about the important factors.

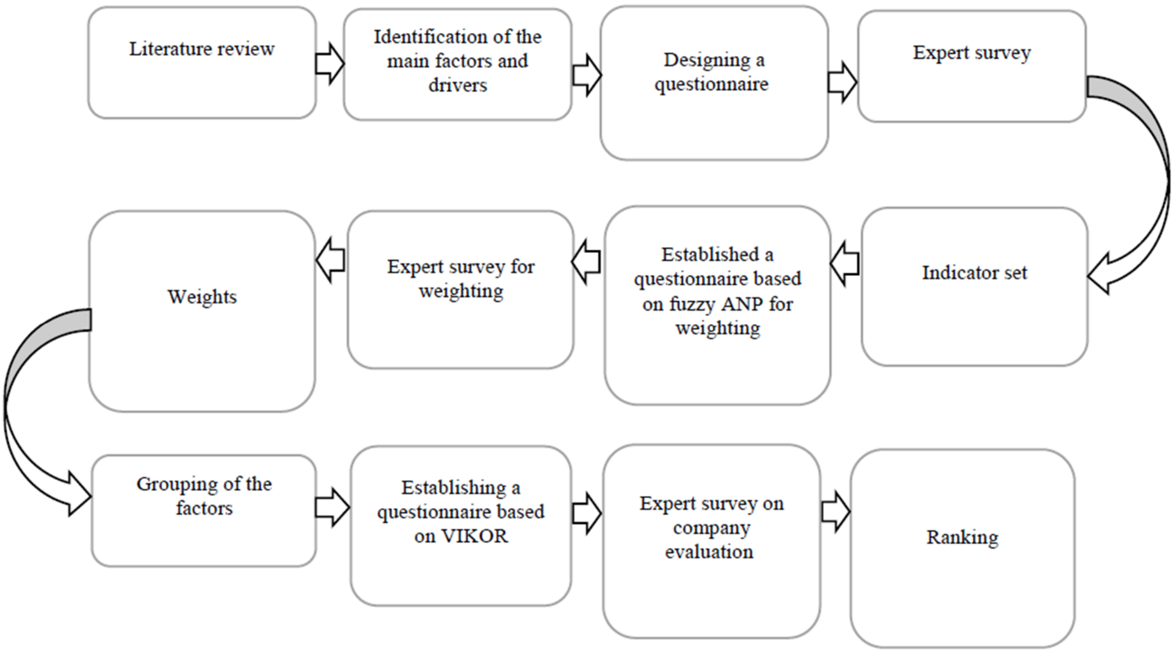

Figure 1. Research framework.

Table 2. Linguistic variables for the Fuzzy ANP and the corresponding triangular fuzzy numbers.

Linguistic Variables	Fuzzy Number	Inverse Fuzzy Number
Same preferences	(1,1,1)	(1,1,1)
Intermediary	(1,2,3)	(1/3,1/2,1)
A little preferred	(2,3,4)	(1/4,1/3,1/2)
Intermediary	(3,4,5)	(1/5,1/4,1/3)
Equally Preferred	(4,5,6)	(1/6,1/5,1/4)
Intermediary	(5,6,7)	(1/7,1/6,1/5)
Preferred a lot	(6,7,8)	(1/8,1/7,1/6)
Intermediary	(7,8,9)	(1/9,1/8,1/7)
Completely Preferred	(9,9,9)	(1/9,1/9,1/9)

Table 3. Triangular fuzzy numbers for evaluation of the alternatives.

Linguistic Variable	Fuzzy Equivalent
Very weak	(0,0,1)
Weak	(0,1,3)
Weak to moderate	(1,3,5)
Moderate	(3,5,7)
Almost good	(5,7,9)
Good	(7,9,10)
Very good	(9,10,10)

In this paper, the Fuzzy Analytical Network Process (ANP) and VIKOR methods are used to find and evaluate the green agile factors and sub-factors. The ANP is a generalization of the Analytic Hierarchy Process (AHP), popularly known as AHP. AHP is a theory of prioritization that derives relative scales of absolute numbers known as 'priorities' from judgments expressed numerically on an absolute fundamental scale [74]. The ANP framework has three basic features, which are useful in multi-criteria decision-making problems: (1) modeling the system's complexity, (2) measuring on a ratio scale, and (3) synthesizing. The local priorities in ANP are established in the same manner as they are in AHP using pairwise comparisons and judgments. However, the supermatrix approach, popularly known as the ANP approach, is becoming an attractive tool to understand more of the complex decision problem as it overcomes the limitation of the AHP's linear hierarchy structure [75].

The aim of Fuzzy ANP is to capture the 'fuzziness' or the vagueness-type uncertainties in the evaluation of remedial countermeasures, particularly, at the initial phase of remediation planning. Due to the complexity and uncertainty involved, as well as the inherent subjective nature of human judgments, it is sometimes unrealistic and infeasible to acquire exact judgments in pairwise comparisons. It is more natural or easier to provide verbal judgments when giving a subjective assessment. Based on the concept of fuzzy logic and the VIKOR method, the proposed VIKOR method has been developed to provide a rational, systematic process to discover the best solution and a compromise solution that can be used to resolve a fuzzy multi-criteria decision-making problem. The proposed VIKOR allows decision-makers to specify the preferred solutions for a given decision problem in real organizational settings [76]. The calculations were carried out by MATLAB and Excel software.

Table 4. Experts' opinion on the importance of factors.

Code	Factor	Sub-Factor	Average
A1	Workforce	New and existing employees' enthusiasm toward learning and training	**7.058**
A2		Teamwork	**7.025**
A3		Multi-skilled and flexible Staff	**7.05**
B1	Market and customer	Matching customer feedback on products	**7.066**
B2		Flexible business	**7.116**
B3		Customer satisfaction rate of new product	**7.258**
B4		Respond quickly to competitors	**7**
C1	Technology	Diversity of equipment, technology, and operational workstations	**7.15**
C2		Level of company's information system excellence	**7.025**
C3		Integration of technology and information	**7.025**
D1	Management	Management's interest in full automation	**7.025**
D2		Management's interest to deliver new models	**7.225**
D3		Promoting a culture of transformation and modernization	**7.041**
E1	Production	Flexible production capacity	**7.433**
E2		Relationship based on trust with suppliers	**7.308**
E3		Innovation in products	**7.55**
E4		Quality standards in the production of new products	**7.041**

3.1. Fuzzy ANP

Saaty [74] introduced the ANP technique in 1996. In this study, this technique was combined with the fuzzy approach. In this research, the triangular fuzzy numbers were used (see Figure 2). Table 4 shows the experts' opinions. In the next paragraph, the Fuzzy ANP steps are shown. Tables 5 and 6 show the super initial matrix and super normalized matrix.

Table 5. Initial supermatrix.

-	**Goal**	**Workforce**	**Market and Customer**	**Technology**	**Management**	**Production**	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**E4**
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Workforce	0.47	0	0.58	0.23	0.14	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Market and customer	0.15	0.49	0	0.29	0.17	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Technology	0.05	0.59	0.23	0	0.13	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Management	0.25	0.56	0.26	0.14	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Production	0.08	0.55	0.25	0.14	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0.25	0	0	0	0	0	0.9	0.1	0.07	0.14	0.21	0.58	0.13	0.73	0.14	0.12	0.27	0.61	0.14	0.15	0.33	0.39
A2	0	0.1	0	0	0	0	0.8	0	0.2	0.56	0.17	0.19	0.07	0.09	0.42	0.48	0.66	0.26	0.08	0.09	0.57	0.16	0.18
A3	0	0.65	0	0	0	0	0.8	0.2	0	0.55	0.09	0.08	0.27	0.09	0.66	0.25	0.11	0.44	0.44	0.22	0.59	0.09	0.09
B1	0	0	0.06	0	0	0	0.08	0.27	0.65	0	0.47	0.08	0.44	0.27	0.11	0.62	0.6	0.2	0.2	0.06	0.54	0.11	0.29
B2	0	0	0.63	0	0	0	0.08	0.27	0.65	0.07	0	0.67	0.26	0.44	0.11	0.44	0.71	0.14	0.14	0.26	0.59	0.06	0.09
B3	0	0	0.25	0	0	0	0	0	0	0.21	0.71	0	0.08	0.56	0.13	0.31	0.54	0.35	0.11	0.26	0.58	0.05	0.11
B4	0	0	0.07	0	0	0	0.08	0.27	0.65	0.72	0.09	0.19	0	0.59	0.3	0.12	0.46	0.32	0.22	0.11	0.51	0.05	0.32
C1	0	0	0	0.65	0	0	0.08	0.27	0.65	0.37	0.16	0.16	0.23	0	0.13	0.88	0.23	0.64	0.14	0.05	0.59	0.17	0.2
C2	0	0	0	0.08	0	0	0.65	0.08	0.27	0	0	0	0	0.2	0	0.8	0.09	0.35	0.56	0.34	0.3	0.12	0.24
C3	0	0	0	0.27	0	0	0	0	0	0.61	0.22	0.12	0.06	0.89	0.11	0	0.67	0.09	0.23	0.1	0.12	0.31	0.48
D1	0	0	0	0	0.27	0	0.67	0.24	0.08	0.37	0.24	0.16	0.23	0.08	0.25	0.67	0	0.83	0.17	0.31	1.14	0.1	0.09
D2	0	0	0	0	0.66	0	0.21	0.71	0.08	0.03	0.3	0.33	0.34	0.64	0.08	0.28	0.88	0	0.13	0.23	0.61	0.05	0.12
D3	0	0	0	0	0.07	0	0.24	0.09	0.67	0.51	0.26	0.17	0.07	0.57	0.32	0.11	0.88	0.13	0	0.6	0.22	0.05	0.12
E1	0	0	0	0	0	0.19	0.1	0.25	0.65	0.04	0.6	0.26	0.1	0.62	0.1	0.28	0.71	0.22	0.08	0	0.24	0.12	0.64
E2	0	0	0	0	0	0.52	0.06	0.71	0.24	0.11	0.24	0.05	0.61	0.59	0.08	0.33	0.72	0.21	0.07	0.61	0	0.1	0.29
E3	0	0	0	0	0	0.08	0.12	0.27	0.61	0.26	0.13	0.04	0.56	0.24	0.1	0.66	0.3	0.09	0.61	0.11	0.25	0	0.65
E4	0	0	0	0	0	0.21	0.71	0.24	0.06	0.45	0.27	0.07	0.22	0.17	0.75	0.08	0.66	0.07	0.27	0.09	0.25	0.66	0
SUM	1	2.2	1.32	0.79	0.5	0.19	4.52	4.22	4.26	4.93	4.17	2.77	4.14	6.17	4.38	6.45	8.32	4.63	4.05	3.57	7.26	2.53	4.27

Table 6. Normalized supermatrix.

-	**Goal**	**Workforce**	**Market and Customer**	**Technology**	**Management**	**Production**	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**E4**
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Workforce	0.47	0	0.25	0.13	0.09	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Market and customer	0.15	0.15	0	0.16	0.11	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Technology	0.05	0.19	0.1	0	0.09	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Management	0.25	0.18	0.11	0.08	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Production	0.08	0.17	0.11	0.08	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0.08	0	0	0	0	0	0.19	0.02	0.01	0.03	0.08	0.14	0.02	0.17	0.02	0.01	0.06	0.15	0.04	0.02	0.13	0.09
A2	0	0.03	0	0	0	0	0.17	0	0.04	0.11	0.04	0.07	0.02	0.02	0.1	0.08	0.08	0.06	0.02	0.03	0.08	0.06	0.04
A3	0	0.2	0	0	0	0	0.17	0.04	0	0.11	0.02	0.03	0.07	0.01	0.15	0.04	0.01	0.1	0.11	0.06	0.08	0.04	0.02
B1	0	0	0.02	0	0	0	0.02	0.06	0.12	0	0.12	0.03	0.11	0.04	0.03	0.1	0.07	0.04	0.05	0.02	0.08	0.04	0.07
B2	0	0	0.27	0	0	0	0.02	0.06	0.12	0.02	0	0.24	0.06	0.07	0.03	0.07	0.09	0.03	0.04	0.07	0.08	0.03	0.02
B3	0	0	0.11	0	0	0	0	0	0	0.04	0.17	0	0.02	0.09	0.03	0.05	0.07	0.08	0.03	0.07	0.08	0.02	0.03
B4	0	0	0.03	0	0	0	0.02	0.06	0.12	0.15	0.02	0.07	0	0.1	0.07	0.02	0.06	0.07	0.05	0.03	0.07	0.02	0.08
C1	0	0	0	0.36	0	0	0.02	0.06	0.12	0.08	0.04	0.06	0.06	0	0.03	0.14	0.03	0.14	0.03	0.01	0.08	0.07	0.05
C2	0	0	0	0.05	0	0	0.14	0.02	0.05	0	0	0	0	0.03	0	0.12	0.01	0.08	0.14	0.09	0.04	0.05	0.06
C3	0	0	0	0.15	0	0	0	0	0	0.12	0.05	0.04	0.01	0.14	0.03	0	0.08	0.02	0.06	0.03	0.02	0.12	0.11
D1	0	0	0	0	0.18	0	0.14	0.05	0.02	0.08	0.06	0.06	0.06	0.01	0.06	0.1	0	0.18	0.04	0.09	0.16	0.04	0.02
D2	0	0	0	0	0.44	0	0.05	0.15	0.02	0.01	0.07	0.12	0.08	0.1	0.02	0.04	0.11	0	0.03	0.06	0.08	0.02	0.03
D3	0	0	0	0	0.05	0	0.05	0.02	0.12	0.1	0.06	0.06	0.02	0.09	0.07	0.02	0.11	0.03	0	0.17	0.03	0.02	0.03
E1	0	0	0	0	0	0.16	0.02	0.05	0.12	0.01	0.15	0.09	0.02	0.1	0.02	0.04	0.09	0.05	0.02	0	0.03	0.05	0.15
E2	0	0	0	0	0	0.44	0.01	0.15	0.04	0.02	0.06	0.02	0.15	0.1	0.02	0.05	0.09	0.05	0.02	0.17	0	0.04	0.07
E3	0	0	0	0	0	0.07	0.03	0.06	0.11	0.05	0.03	0.02	0.14	0.04	0.02	0.1	0.04	0.02	0.15	0.03	0.03	0	0.15
E4	0	0	0	0	0	0.18	0.15	0.05	0.01	0.09	0.07	0.02	0.05	0.03	0.17	0.01	0.08	0.02	0.07	0.03	0.04	0.26	0
SUM	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

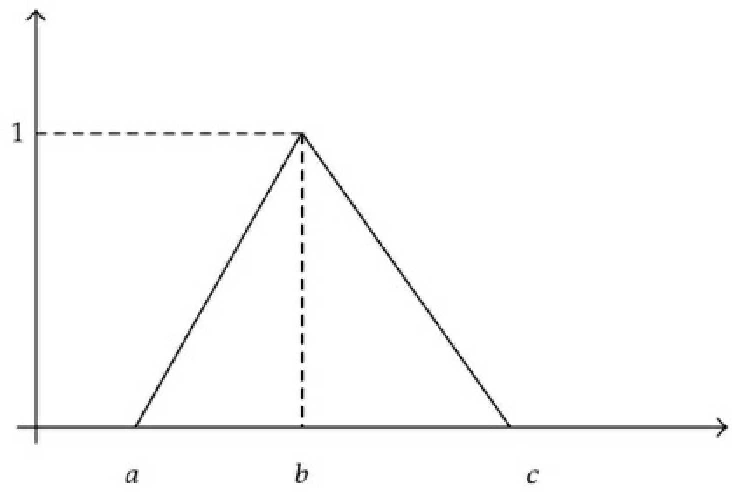

Figure 2. Fuzzy triangular number.

The procedure for implementing the Fuzzy ANP method is as follows:

This method was employed to calculate the priority weights from fuzzy comparison matrices. Chang's method [77] is relatively simpler than other kinds of the Fuzzy AHP method. The steps of Chang's extent analysis method are provided below. Let $X = \{x_1, x_2, \ldots, x_n\}$ be an object set and $U = \{u_1, u_2, \ldots, u_m\}$ be a goal set. According to the method of Chang's extent analysis, each object is taken, and an extended analysis for each goal (g_i) is performed [77]. Thus, m, extent analysis values for each object, can be obtained with the following signs:

$$M_{g_i}^1,\ M_{g_i}^2,\ \ldots,\ M_{g_i}^m,\ i = 1, 2, \ldots, n, \tag{1}$$

where $M_{g_i}^j$ $(j = 1, 2, \ldots, m)$ are triangular fuzzy numbers.

Step 1: The value of fuzzy synthetic extent with respect to the i-th objective is defined as:

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right] \tag{2}$$

To obtain $\sum_{j=1}^{m} M_{g_i}^j$, the fuzzy addition operation of m extent analysis values for a particular matrix is performed as:

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{3}$$

To obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1}$, the fuzzy addition operation of $M_{g_i}^j$ $(j = 1, 2, \ldots, m)$ values are processed as:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \tag{4}$$

and then the inverse of the vector in Eqution (7) is obtained as:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{5}$$

Step 2: The degree of probability of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup_{y \geq x}\left[\min(\mu_{M_1}(x), \mu_{M_2}(y))\right] \tag{6}$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases} \tag{7}$$

where d is the ordinate of the highest intersection point D. To compare M_1 and M_2, we need both the values of V $(M) \geq M_2)$ and V $(M_2 \geq M_1)$.

Step 3: For the degree probability of a convex fuzzy number to be greater than k convex fuzzy numbers, M_i ($i = 1, 2, \ldots, k$) can be obtained as:

$$V\ (M \geq M_1, M_2, \ldots, M_K) = V\ [(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \ldots \text{ and } (M \geq M_K)] = \min V\ (M \geq M_i), \quad i = 1, 2, \ldots, k, \tag{8}$$

Assume that d' (A_i) = min V $(S_i \geq S_K)$ for $k = 1, 2, \ldots, n, k \neq i$. Then, the weight vector is given by:

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \tag{9}$$

where A_i are n elements.

$$d(A_i) = \frac{d'(A_i)}{\sum_{i=1}^{n} d'(A_i)}$$

Step 4: The normalized weight vector elements are:

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T \tag{10}$$

where W contains crisp numbers.

3.2. The VIKOR Method

In this method, at first, surveys are conducted on selected companies' experts, and after examining the sub-factors in their company, they are informed about the desirability of sub-factors in their company. Figure 3 shows the steps involved.

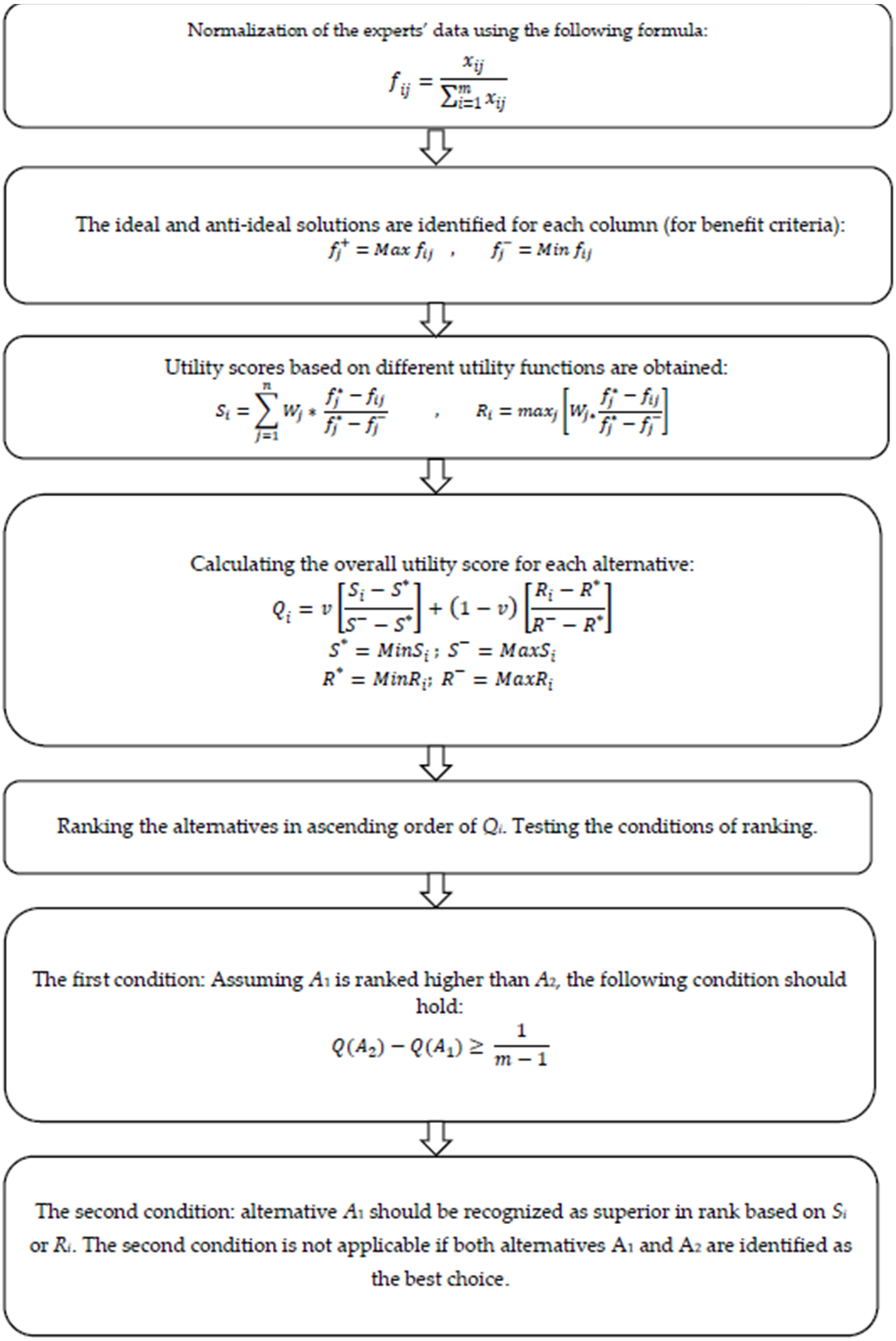

Figure 3. The procedure of VIKOR method.

4. Results

The analysis began with the weight setting. Table 4 shows the experts' opinion about the importance of the selected factors. They prioritized the factors provided in the questionnaire on a scale from 0 to 10. Then, based on the Delphi method, we selected the factors that have got more than seven points on average. Thus, the 17 factors were included in the final list. In the next step, the factors need to be weighted using Fuzzy ANP (see Tables 5 and 6).

After checking the consistency ratio (CR), the weights were transferred to the initial supermatrix (Table 5). However, to use the data, the supermatrix should be normalized. Table 6 shows the normalized supermatrix. The sub-factors' weights are presented in Table 7. These weights show that sub-factors are important (to varying extent) in the decision process. These weights are then used for VIKOR-based decision-making.

Table 7. The weights of sub-factors.

Factors	Code	Sub-Factors	Weight
Workforce	A1	Multi-skilled and flexible Staff	**0.068**
Workforce	A2	Teamwork	**0.0593**
Workforce	A3	New and existing employees' enthusiasm toward learning and training	**0.0627**
Market and customer	B1	Flexible Business	**0.0578**
Market and customer	B2	Matching customer feedback on products	**0.0581**
Market and customer	B3	Customer satisfaction rate of new product	**0.0453**
Market and customer	B4	Respond quickly to competitors	**0.0579**
Technology	C1	Level of company's information excellence	**0.0572**
Technology	C2	Diversity of equipment, technology, and operational workstations	**0.0497**
Technology	C3	Integration of technology and information	**0.05**
Management	D1	Promoting a culture of transformation and modernization	**0.0676**
Management	D2	Management's interest to deliver new models	**0.0575**
Management	D3	Management's interest in full automation	**0.0591**
Production	E1	Quality standards in the production of new products	**0.0601**
Production	E2	Innovation in products	**0.0619**
Production	E3	Relationship based on trust with suppliers	**0.0606**
Production	E4	Flexible production capacity	**0.0673**

Table 7 shows the ranking of sub-factors, which are calculated based on the experts' opinions. Factors with a score of more than 7.0 were chosen. Overall, 17 factors were divided into five groups. For the first group, the workforce is the main factor, and new and existing employees' enthusiasm toward learning and training, team working, multi-skilled, and flexible staff are the sub-factors. The second main factor is market and customer, and matching customer feedback on products, flexible business, customer satisfaction rate of the new product, and respond quickly to competitors are the sub-factors. Technology is the third main factor, including diversity of equipment, technology, and operational workstations, and level of the company's information system excellence and integration of technology and information are its sub-factors. Experts chose management's interest in full automation and management's interest to deliver new models as the management's main factors while promoting a culture of transformation and modernization are the sub-factors for management. Finally, for the last main factor production, flexible production capacity, relationship based on trust with suppliers, innovation in products, and regarding quality standards in the production of new products are selected.

The weights based on the Fuzzy ANP are presented in Table 5. Zero value indicates that there is no relationship between factors or sub-factors. This table is not normalized, and it is termed as the initial supermatrix. Table 6 presents the normalized supermatrix. To obtain the weight of the factors and sub-factors, this table should be solved to get the final weights. Therefore, the final weights are provided in Table 7.

Table 7 shows the obtained weights using the VIKOR method. The data illustrated in this table is employed as the raw data for ranking the companies based on green agility with the VIKOR method. The final factors' weight is presented in Table 7. Afterward, the obtained results were applied to VIKOR in which six tables exist showing all of the steps explained with the VIKOR method.

Table 8 shows the experts' opinions after the normalization process. Then, fj^+ and fj^- for each column are shown in Table 9. The Si and Ri of each company are demonstrated in Tables 10 and 11, respectively. In the VIKOR method, the amounts of S and R are of high importance, and their information is presented in Table 12. The Q amount is the final part of the VIKOR method, which shows the comparison between the companies as illustrated in Table 13.

Table 8. Normalized expert assessments.

Variables	Kalleh	Gella	Haraz	Saleh	Total
Multi-skilled and flexible Staff	0.329	0.111	0.231	0.329	1
Teamwork	0.314	0.151	0.22	0.314	1
New and existing employees' enthusiasm toward learning and training	0.289	0.154	0.203	0.353	1
Flexible business	0.303	0.185	0.278	0.233	1
Matching customer feedback on products	0.269	0.251	0.203	0.277	1
Customer satisfaction rate of new product	0.266	0.173	0.28	0.28	1
Respond quickly to competitors	0.327	0.192	0.231	0.25	1
Level of company's information excellence	0.303	0.284	0.117	0.297	1
Diversity of equipment, technology, and operational workstations	0.262	0.244	0.214	0.28	1
Integration of technology and information	0.297	0.251	0.205	0.247	1
Promoting a culture of transformation and modernization	0.277	0.154	0.258	0.311	1
Management's interest to deliver new models	0.263	0.16	0.277	0.3	1
Management's interest in full automation	0.286	0.157	0.272	0.286	1
Quality standards in the production of new products	0.267	0.27	0.241	0.223	1
Innovation in products	0.318	0.195	0.244	0.244	1
Relationship based on trust with suppliers	0.28	0.238	0.187	0.295	1
Flexible production capacity	0.291	0.232	0.201	0.277	1

Table 9. ${F_j}^+$ and ${F_j}^-$ for each column.

Criterion	${F_j}^+$	${F_j}^-$
Multi-skilled and flexible staff	0.329	0.111
Teamwork	0.314	0.151
New and existing employees' enthusiasm toward learning and training	0.353	0.154
Flexible business	0.303	0.185
Matching customer feedback on products	0.277	0.203
Customer satisfaction rate of new product	0.28	0.173
Respond quickly to competitors	0.327	0.192
Level of company's information excellence	0.303	0.303
Diversity of equipment, technology, and operational workstations	0.28	0.214
Integration of technology and information	0.297	0.205
Promoting a culture of transformation and modernization	0.311	0.154
Management's interest to deliver new models	0.3	0.16
Management's interest in full automation	0.286	0.157
Quality standards in the production of new products	0.27	0.223
Innovation in products	0.318	0.195
Relationship based on trust with suppliers	0.295	0.187
Flexible production capacity	0.291	0.201

Table 10. The values of S_i.

Company	S^i
Kalleh	0.087
Gella	0.75
Haraz	0.621
Saleh	0.204

Table 11. The values of R_i.

Company	R_i
Kalleh	0.02
Gella	0.067
Haraz	0.067
Saleh	0.067

Table 12. The ideal points S and R.

$S+$	0.0878
$S-$	0.75
$R+$	0.02
$R-$	0.067

Table 13. The final utility score Q.

Company	Q	Rank
Kalleh	0	1
Saleh	0.5	2
Haraz	0.895	3
Gella	0.9839	4

Further, the TOPSIS [78], ARAS [79], EDAS [80], and MABAC [81] methods were applied in order to test the robustness of the results. Table 14 presents the results of the comparative analysis. As one can note, there are no differences in regards to the best performing company. However, the ranking of the other companies differs across the six approaches (Tables 13 and 14).

Different Multiple Criteria Decision Making (MCDM) methods follow different principles of data aggregation and calculation of the final utility scores. The results of the ranking procedures based on different aggregation rules basically confirm the effectiveness of the approach proposed in this study. Thus, it can be applied for the multi-dimensional analysis of the performance of a dairy company.

Table 14. Comparative analysis based on different methods.

Method	Company	Utility Score	Ranking
ARAS [79]	Kalleh	0.9624	1
	Saleh	0.9352	2
	Doshe	0.7500	3
	Gella	0.6576	4
EDAS [80]	Kalleh	1	1
	Saleh	0.911	2
	Doshe	0.308	3
	Gella	0.039	4
MABAC [81]	Kalleh	0.3823	1
	Saleh	0.2660	2
	Doshe	–0.1514	3
	Gella	–0.2807	4
TOPSIS [78]	Kalleh	0.853966	1
	Saleh	0.781376	2
	Doshe	0.442795	3
	Gella	0.270683	4
VIKOR [82]	Kalleh	0	1
	Saleh	0.50	2
	Doshe	0.895	3
	Gella	0.9839	4

5. Discussion

In the present era, flexibility in the business market is an important element of any organization in order to be well survived and preserved. If an organization fail to preserve itself with the outside environment, it will lose the competition with rivals and lose their place in the markets. Green agility in any organization is the most important issue and should be taken seriously. Many elements play an important role in each organization's green agility, which we attempted to evaluate in this study. This paper investigated the factors affecting green agility in organizations and studied these factors in dairy companies, such as Kalleh, Doushe, Haraz, and Gela. We also reviewed the green agility of the four companies, compared them with each other, and ranked them based on their green agility. The model presented in this survey was formed by gathering data from several valid sources. The model was evaluated by the view of experts of the companies. After selecting a sub-factor, weighting was done using the Fuzzy ANP after the distribution of the pairwise comparison questionnaires among the experts.

Note that some previous studies, e.g., Papadopoulos [83], suggested that organizations have to adapt to business needs and leap from a traditional system to a green agile. They require improvements based on quality, control, customer perception of the final product, increased communication among team members, and better standards of employee satisfaction. Also, Tanner and Wheeling [84] reported that the effective factors for becoming an agile organization involve culture, customer involvement and commitment, stakeholders participation and sales, team structure and team logistics, project type and planning, and skill level and attitude of the team members.

The results of this study (Table 7) showed that the factors, multi-skilled and flexible employees, promoting the transformation culture and modernization, flexible production capacity, interest of new and existing employees in teaching and learning, product innovation, and relationship with suppliers based on trust and respect, are important to a movement towards green agility. Experts believe that when making a new product, considering the quality standards has the highest impact on the agility of organizations and companies. Multi-skilled and flexible employees are the most important assets of an organization. Employees who are more capable and multi-skilled have the ability to help the organization when needed [85].

An organization may require an employee to work in another part, and the multi-skilled employee will help the organization to meet its customers' needs and compete with the rivals. Promoting the culture of change and modernity: culture transformation and modernization are important factors in an organization to be well adapted as quickly as possible with their outside environment. As organizations promote the culture of change and renewal, employees will know the meaning of premature change more easily and cooperate better in order to make necessary changes to their organization. Flexible production capacity: in the present era, customers' needs are not completely consistent with the development of technology and up-to-date products. Customers are attracted to new products; thus, companies need to make their capacity flexible in order to meet the needs of previous clients, keep them, meet the needs of new customers, and to compete with their counterparts in the field of business without falling behind. The threat of falling behind and losing the business entirely to a competitor actually makes the company continue working hard [86].

The interest of existing and new employees in teaching and learning: motivation and satisfaction among employees of an organization will enhance the growth and excellence of creativity in organizations and can provide solutions to respond to competitors and the market. Discussion about employee training is one of the most important responsibilities of organizations to make their employees ready toward the threads and new opportunities in order to take the greatest advantage of their expertise and ability. Nowadays, products change and progress faster than we think. The longevity of the products has come down to such an extent that the organization has to think about what the next product will be at the beginning of launching a new product. The more a product helps the customers, the more it will be accepted by them.

Trust-based relationship with the suppliers: it is one of the most important factors in the green agility of an organization [87]. If an organization can establish a better relationship with its suppliers and rely on them in terms of preparing raw materials or making any change to the materials, it is able to respond to the market needs and be well adapted to changes that may occur in the market. The faster such adaptation occurs, the greener is the organization. Kalleh is one of the examples of such an organization. Concerning the quality standards to produce a new product: the quality is always the choice of the customer and is the sign of superiority of one company over the other. Paying attention to quality standards will enhance the quality of the products [88]. It will be easier for customers to choose the products, and with an improvement in quality, customers will choose the products more easily. Every organization needs to attempt to continuously improve the quality to have an advantage in competition with their peers.

6. Conclusions

The paper proposed a methodology for assessment of the green agility of the dairy companies. Taking the example of Iran, the results indicated that Kalleh Company was greener than the other companies because of product innovation and enthusiasm of employees to learn, which has made this company the best, as shown in Table 13. In addition to the competition in the domestic market, this company considers exporting its products outside the country borders. This shows the competency of the company in all areas of production, management, and staff. Each factor involves important sub-factors for making the selected dairy companies agile. The important sub-factors of agility are: agility in the workforce, multi-skilled and flexible employees, market dimensions and customers, the implementation of customer feedback on products in terms of the variety of machines in operation and workstation in technology dimension, agility management, promoting the culture of innovation and transformation, and trust-based relationship with the suppliers in production dimension.

This study has some limitations. First, the considered factors and expert assessments regarding their importance may vary across companies as experts might have ignored some factors. Second, expert ratings may be biased due to the goal of the study. Anyway, the results obtained are plausible given the trends prevailing in the market. Finally, data collection is highly cumbersome as the companies do not want to reveal their information due to competition. In this paper, a new method was proposed to measure the Iranian dairy company's green agility. The factors were identified related to the company's green agility. Some suggestions for further research in this field involve using Fuzzy MCDM to find the important factors in dairy companies' supply chain based on green agility. The holistic paradigm and associated methodological tools [89–92] can decrease the environmental pressures and allow responding market demand quickly. Thus, this system can decrease environmental damage and increase performance with a high level of corporate social responsibility.

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