Int. J. Nonlinear Anal. Appl. 14 (2023) 1, 1027–1045
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2022.21736.3586

Factors affecting the identification and prioritization of export industrial clusters of Iran to the eurasian economic union (case study: Gilan province)

Ramin Yousefzadeh, Hossein Bodaghi Khajeh Noubar*, Yaghoub Alavi Matin, Nasser Feqh-hi Farahmand

Department of Management, Tabriz Branch, Islamic Azad University, Tabriz, Iran

(Communicated by Madjid Eshaghi Gordji)

Abstract

Today, organizations face competitive environments and always need radical and fundamental change. This competitive environment forces organizations to abandon their fixed work methods and replace them with new ones to make fundamental changes. Industrial clustering is conducted in almost all countries worldwide, and Iran tends to consider industrial clusters in scientific and decision-making meetings in decision-making and development programs. Competitive necessity is the essential issue of clustering and cluster-based policies. Therefore, this study aimed to identify and prioritize the effective factors in the industrial export clusters of Iran to the Eurasian Economic Union (case study: Gilan Province). This applied research employed a field implementation method and questionnaire and interview tools as exploratory research with quantitative and qualitative data. The validity and reliability of the questionnaires were confirmed. The population was industry experts and some professors in the industrial export clusters who were selected as a statistical sample through convenient judgment sampling (15 people) for localization of the model. Data collection was prepared and adjusted through a researcher-made questionnaire based on pair-wise comparisons of the mentioned components. Fuzzy DEMATEL methods and fuzzy network process analysis were used to analyze the data in Excel. First, the criteria were identified, and then its content validity was confirmed by university professors by studying and reviewing scientific texts. In addition, the reliability of the indices was confirmed by Cronbach's alpha greater than 0.7. Then, seven main factors and 21 important sub-factors were identified using the scoring technique. In the next step, the effectiveness of each factor was determined using the fuzzy DMATEL technique (F.DMATEL). The "governmental factor" with an impact value of 1.49 was the most influential, and the "Company structure factor" with a net impact value of -1.174 was the most impressive. The identified factors were prioritized with Fuzzy Network Analysis Process (F.ANP) technique. The results showed that the maximum weight is related to the company structure criterion. The factors of company structure, suppliers, resources, markets, infrastructure, and economy were in the next ranks, respectively. Finally, some recommendations were provided to senior managers and experts of Iran's export industrial clusters to the Eurasian Economic Union, especially in Gilan province.

Keywords: Industrial clusters, Export, Fuzzy multi-index decision-making, Fuzzy DMATEL, Fuzzy network analysis process
2020 MSC: 03B52, 90C70

*Corresponding author
Email addresses: yousefzadeh.ramin@yahoo.com (Ramin Yousefzadeh), h_budaghi@yahoo.com (Hossein Bodaghi Khajeh Noubar), alavimatin@iaut.ac.ir (Yaghoub Alavi Matin), farahmand@iaut.ac.ir (Nasser Feqh-hi Farahmand)

Received: February 2022 *Accepted:* May 2022

1 Introduction

Industrial development has given way to sustainable development in recent centuries, and environmental consequences and the unresponsiveness of the planet's resources have become a primary human concern [13]. Job protection is essential for economic policies in all market economies, and today foreign trade is one of the most fundamental economic issues [8]. One of the challenges and issues in countries is the unfavorable employment situation [30]. Industrial development is one of the programs considered in the form of development needed to facilitate investment in most countries. Government determination and commitment to providing grounds for encouraging and supporting developing industries and the export of industrial goods are essential factors for the success of this strategy [12]. In this regard, many studies have revealed the importance of development in solving the problems of poverty and unemployment and its positive impact on prosperity and economic well-being [49].

Given that a significant part of economic activities is carried out by small and medium-sized companies worldwide, governments think of rational support for these companies to increase their competitiveness with various measures to compete in the competitive markets of the world [22]. One of the scientific solutions for developing industries is industrial clusters [6]. Industrial clusters help grow and strengthen the economy by generating new and coordinated skills and revenue. Therefore, industrial clusters in the regions cause production and economic stability creating sustainable jobs and producing new products [17]. Identifying and developing industrial export clusters can create employment, generate income, specialize businesses, and create entrepreneurship [4]. Researchers have introduced competitive strategies such as providing solutions by the government to increase the marketability of industrial products and establish communication between producers by strengthening the competitive structure for developing rural home-based businesses.

An industrial cluster concentrates on small and medium-sized firms with a historical background in a geographical area (mainly in metropolitan areas and their suburbs). These firms cooperate and compete for optimal resources, achieve various benefits, and face similar challenges and opportunities by increasing their knowledge and innovations [3]. Clusters are appeared based on geographical proximity, develop over time, and strengthen competitiveness and participation. Clusters drive innovation and potentially generate higher economic benefits through greater productivity, better knowledge management, and entrepreneurial opportunities for regional growth and economic benefits, knowledge production, and transfer. A thriving cluster can be the driving force behind developing a particular industrial area with a regional economy [16]. Since Knowledge Management and Reverse Logistics are in favor of similar bases, Reverse Logistics needs Knowledge Management at return of the product. Thus, taking reverse logistics into consideration can bring about more advantages for the company [31].

Creating a competitive need is an essential issue in clustering and cluster-based policies. Porter considered the advantage of competition as a vital issue in industrial clustering policies and emphasized the competition between firms and internal and external dependencies and their impact on industry growth and innovation [28]. The importance of the factors influencing the creation of business clusters varies in regions. Therefore, recognizing the factors affecting the formation of business clusters in each region is one of the primary and essential needs that planners need [17]. Creating industrial clusters is always associated with high uncertainty and complexity [37]. Research in various processes of industrial clusters has a high priority in creating a culture of protecting the environment, quality, and performance improvement due to the special position of industrial clusters as one of the most important competitive advantages of the country and the basis for creating economic revenues. Environmental, social, and export considerations should be included, emphasizing the production and export of quality products that require a proper supply chain in industrial clusters. In addition, industrial export clusters should be used instead of traditional exports. Therefore, the importance of this research is to accurately and comprehensively identify and prioritize the effective criteria for industrial export clusters in Gilan province and provide appropriate solutions. The costs of lacking export industrial clusters in the current competitive environment are irreparable. Hence, further studies are necessary to better study the criteria affecting the export industrial clusters in Gilan province.

Export industrial clusters need new methods of production and export due to increasing competition in domestic and regional markets for their development and survival. The competitiveness of companies can also be reinforced by people as thought leaders. To put it simply, social media in the form of electronic word of mouth advertising (eWOM) can increase the popularity of a company, since customers trust the opinions of old customers in their purchase [27].

Global sanctions, customer dissatisfaction, lack of proper product quality, production of air pollutants, harmful wastes, and increase in carbon dioxide in the air faced activities of industrial export clusters with problems, which has jeopardized their competitive advantage. Brand equity can be regarded as a factor which can affect customer lifetime value (CLV) in the competitiveness of companies. A significant positive effect can be observed between brand equity and CLV (71). In other words, brand equity directly and indirectly influences CLV in the competitiveness of the

banking industry and the significance of profitability in this domain [45]. The problem that managers and planners of companies operating in these export industrial clusters face is influential factors in export industrial clusters to prevent failure and loss of their market. In addition, numerous and diverse decision indicators affecting export industrial clusters and multiple goals like export industrial clusters caused the issue of export industrial clusters in decision theory as a challenging issue in the management literature. The main problem of this research was to present a combined multi-criteria fuzzy decision model to identify and prioritize the factors affecting export industrial clusters in Gilan province.

2 Research literature

2.1 Theoretical foundations

Industrial clusters were implemented many years ago, flourishing since the 1990s in European countries such as Spain, France, and Italy. Michael Porter (1990) focused more on industrial clusters in "Competitive Advantage." Hence, a "Porterian cluster" was defined as a geographically adjacent group and affiliated companies and affiliated institutions in a specific field related to commonalities and external relations [9]. The first ideas about firms' clusters were published by Alfred Marshall in the book Principles of Economics. Since then, many researchers have analyzed the forms of enterprise clusters in different historical and geographical contexts and different epistemological contexts [43]. Clusters have been recognized as one of the ways to overcome the limitations of small and medium firms over the past decades, whereby geographical proximity increases productivity, innovation, and competitiveness of regions [50]. Marshall first stated theoretical support for the phenomenon of cluster formation in the theory of the economic benefits of clustering [4]. Then, Michael Porter, in a book entitled "Comparative Advantage of Nations," specifically proposed the theory of industrial clusters for the first time. He proposed another type of approach to analyze issues related to regions, in which the position of firms in the length and width of each other and their vertical and horizontal relationships and interactions with national and local institutions, and all factors involved in the production process were examined as "cluster" [19].

According to this theory, small companies become members of an independent network while being natural competitors. Cluster means the geographical concentration of the institutions of related companies in a specific field [4]. Cluster refers to the spatial concentration of economic activities in a particular field. Policymakers consider these clusters because of collective efficiency opportunities that stem from external economic benefits, low transaction costs, and collective action. Spatial aggregation of unrelated companies cannot increase collective efficiency, and external interactions and effects are considered. Thus, a cluster is a relatively large group of enterprises in a specific location with specialized background and significant inter-firm trades (cluster). In other words, the centralization and geographical concentration of firms are called clusters, leading to external savings. Clustering attracts brokers in remote markets and contributes to the emergence of specialized services in the technical, financial, and managerial fields [29]. Being a member of an industrial cluster is essential for professional companies because of facing a high level of resource constraints in finance, as well as product marketing, which are overcome through spatial links and possible relationships between its members. The concept of clustering was promoted as a powerful driver of economic growth in developing economies [10]. Industrial clusters enable businesses and institutions in their activities and create employment, production of products and provision of services, added value[47]. creates employment, production of products and services, and added value. Creating appropriate clusters creates new jobs and improves the economic situation and growth of countries. Clusters and small businesses increase job opportunities and financial benefits [24]. Clusters have challenges and issues in every business. Studies have shown that institutional weaknesses such as lack of the implementation of legal contracts and instability of markets and political conditions generally distinguish clusters in developing countries from developed ones. However, there is more confidence in the business environment in developed countries [10].

2.2 Industrial cluster

According to Porter's (1990) theory, clustering is an effective way to strengthen the competitiveness of companies operating in different business sectors. Firms in the cluster have a more remarkable ability to reach larger local markets and are encouraged to be more creative because of competition between companies in the cluster. Many studies have confirmed the significant role of clustering in improving industry competitiveness and product quality [9]. Small industries can achieve competitiveness through clusters. According to Diamond Porter's model, competitiveness is the result of the interaction of four internal (domestic demand conditions, related and supporting industries, strategic and company structure, and competition) and two external factors (government and unforeseen events) [2]. The growth of

small business units, the main economic base of millions of poor people in developing countries, is generally seen as a primary measure to reduce poverty, widening income inequality, and increase unemployment. These small businesses can be in both industry and agriculture [38], a group of companies with solid vertical links located in an area not necessarily geographically close to each other. Porter's second and newer definition of a cluster is the geographical concentration of related institutions and companies in a particular area [28]. Industrial clusters are business units concentrated in a geographical area on an industrial trend and produce and supply several goods and services by cooperating and completing other activities with common challenges and opportunities [8]. Given the following points, "An industrial cluster is a set of commercial and non-commercial firms concentrated in a geographical location and economic zone and establish vertical and horizontal connections to produce one or more similar and related end products for external economic benefits. The mentioned firms compete in many cases of cooperation and joint actions. The internal communication of these companies reduces costs and facilitates access to inputs, knowledge, and technology to produce sales markets and meet customer needs [42]. First, the activities with the basis for the formation of industrial clusters should be identified using the correct information and based on documented and reasoned calculations to establish industrial clusters in a region. Then, the appropriate infrastructure (physical, social, legal, and cultural) for industrial clusters should be evaluated, and their shortcomings in the region should be eliminated [4].

2.3 Multiple criteria decision-making

Human thinking is associated with uncertainty in many decisions, affecting decision-making. Therefore, it is better to use fuzzy decision-making methods [44]. Zimmerman [51] stated that rates and weights multiple criteria decision-making are evaluated as uncertain, vague, and ambiguous and are usually expressed as speech variables and consequently fuzzy numbers [40]. Multi-criteria decision-making aims to determine the best option while it can create the most satisfaction [35]. The multi-criteria decision-making is proposed for problems with ambiguity and uncertainty [18].

2.4 Fuzzy set

A fuzzy set contains elements with different membership values [11], in which the membership is relative and not completely definite. A generalized fuzzy set is a classic set, which allows any value belonged to the range. In fuzzy sets, unlike definite sets, elements are not divided into members and non-members, and the membership of different elements in fuzzy sets varies between zero and one. Fuzzy numbers are a relative type of fuzzy set [1]. In other words, the condition for an element to join or not join a set does not depend on whether or not it is entirely part of that set. An element may have a higher membership rating or a lower membership rating in a set than another. Since the membership of an individual or element in a fuzzy set may be associated with uncertainty, it is expressed in the form of degree. Fuzzy set theory is a complete tool for modeling the uncertainty and inaccuracy that emerged from the human mind, neither accidental nor probabilistic. Fuzzy logic provides a systematic basis for dealing with situations that are ambiguous or not well defined [7].

2.5 Research background

Akhmadeev et al. studied industrial and agricultural clusters supporting food security in a developing market economy, considering a mechanism of creation and implementation of agricultural and industrial clusters in rural areas. The municipal organization is an average population center whose inhabitants are engaged in agriculture and guarantee its functioning. The social infrastructure of the cluster is a combination of a system of production, primary processing, storage, and marketing of agricultural products, which guarantees the quality of life of its inhabitants. This study indicated that the proposed mechanisms to ensure government food security with the aim of integrated development of rural settlements, include additional budget allocation and adjustment of tax policy for agricultural producers [3]. Linsko et al. examined the educational and industrial clusters as advanced specialized education to discuss creating a conceptual framework for activating educational and industrial clusters as prospective vocational training in the secondary vocational education sector. In addition, the importance of improving the vocational secondary education system to support and contribute to the innovative social and economic development of the regions was also emphasized. General scientific methods such as systematic and dialectical were used for analysis. In the modeling and implementation phase, the authors used special methods such as experimental data collection, recording, and processing and applied a logical method to interpret the received data. Specific sociological methods were used in the initial stage of the research and the experimental stage. Specific sociological methods were used in the initial and experimental stages of the research, which provides a brief overview of creating a cluster, its characteristics,

and its basic goals and strategies. Special attention was paid to the educational and industrial cluster, its structure and performance, and establishing a regional center for advanced vocational training. This paper also described the educational and industrial cluster development stages and presented some learning outcomes [29]. Ayakwah et al. analyzed competitive relationships or cooperation in international clusters in Ghana. The findings showed that industrial clusters with a more formal business structure tend to have at least horizontal competition but higher vertical cooperation. Comparatively, clusters with a more social internal environment tend to have a higher level of cooperation and minimal competition in vertical and consonant relationships. The study also found that such changes in business interrelationships affect access to finance jobs, formal contracts, innovation sharing, and their relationship with different stakeholders in the supply chain. This research also shows how the unique characteristics specific to developing economic situations are the key to the sustainable maintenance of the activities of clusters based on structural equations [10]. Naminse et al. examined the relationship between entrepreneurship in industrial clusters and rural poverty reduction in China. The results indicated a statistically significant and positive relationship between entrepreneurship and rural poverty reduction in China. Further research findings showed that the qualitative growth of entrepreneurship positively reduced rural poverty compared to quantitative growth, and the socio-cultural capabilities of respondents significantly affected the entrepreneurial growth of farmers instead of education and economic abilities [36]. Awad and Amro studied the effect of clustering on improving competition and showed that clustering could succeed in small and medium competitions. Relationships between clusters and competition may provide practical clues for policymakers and researchers to strengthen skilled labor, research, development capacity, and infrastructure, likely to create assets such as trust, synergy, and collaboration to improve competition [9]. Connell et al. studied four industry clusters in Australia and the UAE and found that industrial clusters significantly affected the growth of both developed and new economic development sectors. Proper management and facilitation of this cluster, company cooperation, knowledge sharing, and innovation can lead to positive results and foster knowledge sharing. Cluster managers/facilitators should provide regular opportunities for cluster facilitators or representatives to network and develop new ideas [15]. Hoang et al. conducted a study in rural areas of Vietnam and showed that the diversity of non-agricultural activities could be an important tool for reducing poverty for rural families. Involvement in the agricultural sector increases agricultural productivity, but employment in the agricultural sector reduces farm working hours and does not affect household agricultural income [21]. Asgari [8] investigated the factors affecting Iran's exports to the Eurasian Economic Union using the model of gravity and panel data from 2007-16. The results of the generalized torque estimator showed that the variables of GDP size, economic similarities, the difference between exporter and importer income, and real exchange rate were effective in increasing Iran's exports. The establishment of a preferential trade agreement between Iran and the Eurasian Economic Union increase Iran's exports by 43%. Accordingly, strengthening the transport and maritime trade infrastructure in the northern coasts of the country, fortifying the road infrastructure, and completing the railway connection from the Julfa border to Makri, Armenia, and the use of national currencies in trade between the two countries are suggested according to the current situation. Elahi et al. examined the potential effects of a trade agreement between Iran and the Eurasian Economic Union on industry and agriculture export sectors using an attraction model approach. To this end, three coding steps, including open coding, axial coding, and selective coding, were performed after collecting the research data. The presented model had seven main dimensions and 25 sub-dimensions whose relations in the model were based on cause-and-effect relationships. The results showed that the sustainable development of industrial clusters should be performed continuously and comprehensively, and environmental and social factors should be considered in the development process, in addition to economic factors. The proposed model had a comprehensive and multidimensional approach to developing industrial clusters, which could be used by development actors to achieve sustainable development. The business environment and development conditions of industrial clusters in Iran were considered in this model. Anvari et al. [6] conducted a study to identify and create industrial clusters in Bushehr Province. This study analyzed the strategic interaction of two governments and two firms exporting the same goods to the global market using game theory. This interaction was examined in the form of a dynamic two-stage game with complete but incomplete information. In the first stage, governments decided whether or not to pay R&D subsidies to their firms, and in the second phase, firms decided whether or not to allocate funds to R&D. The full balance of this unique subsidiary game reflected governments 'support for their firms, as well as firms' determination to allocate money to research and development. Although this result may lead to a prisoner puzzle for governments in developed countries under certain conditions, it is an optimal solution for developing countries, including Iran. The achieved balance was also in line with the implementation of the general policies of the resistance economy. Heidari [20] researched to develop a business cluster of horticultural products with an emphasis on processing industries in Kermanshah province. The results showed that the causal conditions were the geographical focus, trust, cooperation and competition, common opportunities, and challenges facing businesses. Entrepreneurship and collective identity, access to appropriate infrastructure, human resources, market, regional economic prosperity, and appropriate technology were the contexts of cluster development. Cluster development, climate change, sanctions, and startups were also the intervention factors, which attracted government support and support institutions, busi-

ness coordination, labor training, and effective service delivery to businesses as strategies for developing horticultural clusters in Kermanshah province. Finally, the consequence of developing horticultural clusters included agricultural development, economic development of the region, market development, human development, and socio-cultural development. Sharifzadeh et al. discussed the role of agricultural and industrial clusters in developing rural businesses in Mazandaran province. The factor analysis of the consequences of forming business clusters led to the extraction of six factors: 1) promoting agricultural economic development, 2) improving social development, 3) increasing production capacity in the agricultural sector, 4) development of agricultural entrepreneurship, 5) growing agricultural products market, and 6) enhancing human capital in the agricultural sector [46]. Masaeli evaluated the feasibility of establishing production cooperatives for home and family businesses from technological factors in production cooperatives and home businesses in Semnan province. The results revealed that technical and communication factors are essential in the feasibility study of creating production cooperatives for home and family businesses, respectively. The highest rank among the technical and technological sub-indicators was related to the sub-index of ease of technology hardware repairs. The highest rank among the two indicators of communication parameters and capabilities of the production unit were the indicators of development and improvement of relations with suppliers and promotion of technological capabilities (knowledge and experience of using technology), respectively [30]. Manvarian et al. explained the policy model for developing business clusters in Iran. According to the findings, cluster development involves value chain improvement, market development, technology development, and human resource development. In addition, the vital cluster development policies can be listed at the national level, culture building and segmentation legitimacy at the provincial level, institutional networking, cluster identification and prioritization, trust-building, and business network development at the cluster level. The most important consequences of cluster development are the synergy of policies and reducing social problems at the macro-level [34]. Erjaei ranked the factors affecting the establishment of rural business clusters in Charam city. The results showed that the economic criterion was the most important, and the infrastructure criterion was the least important for creating business clusters in Charam city [17]. Jivar analyzed the factors affecting business development in agricultural and industrial clusters in Mazandaran province. The results indicated the factors in seven categories, including the effective provision of business services, business coordination, facilitation of business functions, institutional empowerment of the business environment, human resource training, quality management, and facilitating joint ventures [24]. Khalesi (2016) prioritized the network and advantageous business clusters in Semnan province by the AHP method, and the auto parts cluster is ranked first [26]. Naieji explained the factors affecting the formation of business clusters in Mazandaran province. Innovation, strategy, structure, and competition, directly and indirectly, affected the formation of business clusters of higher education. Janatifar [**?**] investigated the factors affecting the creation and development of industrial clusters in Isfahan province and their prioritization using the ANP approach. The spatial and spatial factors were identified as the essential factor, and social and cultural factors were specified as the least important factors after analyzing the data and prioritizing the factors affecting the creation and development of industrial clusters in Isfahan province [2]. Spatial and spatial factor 2. Policy and institutional factor 3. Economic factor 4. Organizational factor 5. Social and cultural factor) [**?**]. Mir assessed the feasibility of establishing fisheries industrial clusters in the Chabahar region using fuzzy data hierarchical analysis (AHP). The study criteria were integration strategy, ultrastructure, and resources. The result showed that a forward strategy is critical in creating an industrial cluster [32]. Therefore, several factors affect the industrial clusters of exports. These factors, individually and in combination, are important preconditions for export industrial clusters because of affecting the export industrial clusters. Table 1 presents the indicators and sub-indicators affecting export industrial clusters:

3 Method

This exploratory and cross-sectional study was conducted on the experts of industrial clusters of the studied province and several expert professors in export industrial clusters. According to the definition of the statistical community, the statistical sample included experts who were thoroughly acquainted with the subject of export industrial clusters scientifically and practically and had operational or research activities in this field in determining the priority of components in two groups. The first group was managers and senior experts of the study organization (15 people), who were screened to localize the model and check the content validity of the model and factors using a mathematical model. The second group was a community of experts due to research techniques in fuzzy DEMATEL operations and methods. According to Saaty (2002), eight experts related to the organization under study were selected by convenient sampling method, who owed master's and doctoral degrees and more than 12 years of experience. The research literature was reviewed to collect information, and experts' opinions were utilized to identify the factors. Two types of questionnaires (screening questionnaire and pair-wise comparison questionnaire) were used to collect the necessary data during the research. Cronbach's alpha was used to assess the validity of the first questionnaire, which is collected

Table 1: Indicators and sub-indicators affecting export industrial clusters

No.	Indicators	sub-indicators	Researchers (year)
1	Suppliers	Cooperation with related industries	Hashemi et al. [19], Farajpour Khanapashtani et al. [39], Salarzehi et al. [42], Aboui Ardakan et al. [2], Ayakwah et al. [10], Awad et al. [9], Paul et al. [38], Sarturi et al.[43]
		Strong suppliers	
		Major activities of production workshops	
2	Company structure	Sales policies	Hashemi et al. [19], Farajpour Khanapashtani et al. [39], Alizadeh Thani et al. [4], Salarzehi et al. [42], Aboui Ardakan et al. [2]. Ayakwah et al.[10],Awad et al.[9], Paul et al. [38], Sarturi et al. [43]
		Strong competitors	
		Management capability	
		Competitive price	
3	Markets	Market perspective	Hashemi et al. [19], Farajpour Khanapashtani et al. [39], Salarzehi et al. [42], Aboui Ardakan et al. [2], Ayakwah et al. [10], Awad et al. [9], Paul et al. [38], Sarturi et al. [43]
		The size of the markets	
		Demand	
		Geographical distance	
		Barriers and restrictions of the market	
4	Infrastructures	Communication infrastructure	Hashemi et al. [19], Farajpour Khanapashtani et al. [39], Salarzehi et al. [42], Aboui Ardakan et al. [2], Ayakwah et al. [10], Awad et al. [9], Paul et al. [38], Sarturi et al. [43]
		Transportation infrastructure	
		Business environment	
		Local factories and workshops in the area	
5	Resources	Human resources	Hashemi et al. [19], Farajpour Khanapashtani et al. [39], Salarzehi et al. [42], Aboui Ardakan et al. [2], Ayakwah et al. [10], Awad et al. [9], Paul et al. [38], Sarturi et al. [43]
		Fund	
		Technology	
6	Economic factors	Value chain breadth	Hashemi et al. [19], Farajpour Khanapashtani et al. [39], Salarzehi et al. [42], Aboui Ardakan et al. [2], Ayakwah et al. [10], Awad et al. [9], Paul et al. [38], Sarturi et al. [43]
		Competitiveness	
		Transaction cost reduction	
		Economic efficiency	
7	Governmental agents	Government incentive policies	Hashemi et al. [19], Farajpour Khanapashtani et al. [39], Salarzehi et al. [42], Aboui Ardakan et al. [2], Ayakwah et al. [10], Awad et al. [9], Paul et al. [38], Sarturi et al. [43]
		Government protection policies	
		Public sector investments	

for the importance of criteria and sub-criteria. According to this method, the reliability of all research variables was more than 0.7.

4 Data analysis method

The fuzzy method was used to consider mental issues and uncertainties in decision-making and perform pair-wise comparisons of model factors with a higher capability than other similar methods. The Fuzzy Delphi technique was used for screening to identify the factors affecting the green supply chain to analyze the data collected from the questionnaire. The Fuzzy Decision-Making Trial and Evaluation Laboratory (F.DEMATEL) was applied to prioritize the Fuzzy Analytical Network Process (F.ANP), and the solution method was based on Tzeng et al. The mentioned method are described in the following:

4.1 Fuzzy dematel method

The Fuzzy DEMATEL method examines the structure of effects between criteria [48] and tries to solve the organizations' problem and improve it by using group decision-making in fuzzy conditions [5]. The steps of this method are as follows:

Step 1: Creating a fuzzy direct relation matrix by determining the effect of criterion i on j with the guidance of Table 2. Step 2: Normalizing the direct relationship matrix through Equations 1 and 2:

Table 2: Linguistic scales for pair-wise comparisons [40]

Fuzzy numbers	Linguistic words for pair-wise comparisons	
(0.75, 0.75, 1)	$\widetilde{4}$	Very high impact
(0.5, 0.75, 1)	$\widetilde{3}$	High impact
(0.25, 0.5, 0.75)	$\widetilde{2}$	Low impact
(0, 0.25, 0.5)	$\widetilde{1}$	Very low impact
(0, 0, 0.25)	$\widetilde{0}$	Effectless

$$\widetilde{X} = K.\widetilde{X} \tag{1}$$

$$k = min\left[\frac{1}{max_{1\le j\le n}\sum_{j=1}^{n}\widetilde{A}_{ij}}, \frac{1}{max_{1\le i\le n}\sum_{i=1}^{n}\widetilde{A}_{ij}}\right] \tag{2}$$

Step 3: Calculating the general relationship matrix with Equation 3.

$$\widetilde{T} = \widetilde{X}(1-\widetilde{X})^{-1} \tag{3}$$

Step 4: Determining and using Equations 4 to 6:

$$\widetilde{T} = [\widetilde{t}_{ij}]n \times n, \qquad i,j = 1,2,...,n \tag{4}$$

$$\widetilde{R} = [\sum_{j=1}^{n} t_{ij}] = [\widetilde{t}_i]n \times 1, \tag{5}$$

$$\widetilde{D} = [\sum_{j=1}^{n} t_{ij}] = [\widetilde{t}_j]1 \times n, \tag{5}$$

Step 5: calculating $(\widetilde{R}+\widetilde{D})$ and $(\widetilde{R}-\widetilde{D})$ and plotting the effects relationships in the coordinate axis.

Step 6: Forming a boundary supermatrix

The weighted supermatrix converges through relation $\lim_{k\to\infty}(W^{\alpha})^k$ to form a finite supermatrix, and finally, the final weights are determined by the D.ANP method.

4.2 Network Analysis Process (ANP)

The network analysis method was proposed by Saaty and Takizawa [33]. The process of network analysis is the general state of AHP and its extended form, which has all the positive features such as simplicity, flexibility, applying quantitative and qualitative criteria simultaneously to examine the consistency of judgments and make complex relationships (interdependencies and feedback) between and between decision elements by a network structure instead of a hierarchical structure. The difference between a "hierarchical structure" and a "network structure" is presented in Figure 1. The Network Analysis Process (ANP) considers each problem as a "network" of criteria, sub-criteria, and options (all of which are called elements), which are grouped in clusters. All elements in a network can be related to each other. In other words, in a network, feedback and interaction in and between clusters are possible. Therefore, the network analysis process can be considered in two parts (control hierarchy and network communication). The control hierarchy includes the relationship between the goal, criteria, and sub-criteria and affects the internal communication of the system, and the network communication includes the dependence between elements and clusters. This feature of the network analysis process makes it possible to consider the interdependencies between the elements and thus provides a detailed approach to complex issues. The effect of an element on other elements in a network is considered by a supermatrix [41].

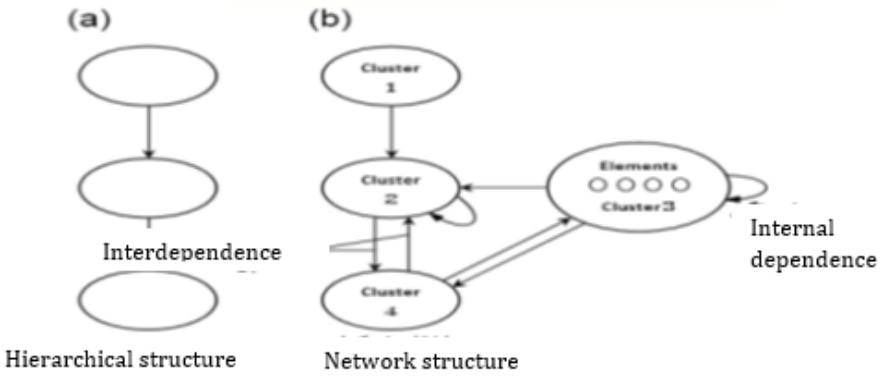

Figure 1: Structural differences between a "hierarchy" and a "network" (Source: [14])

4.3 Fuzzy analytic network process (ANP)

The Fuzzy analytic network process is very appropriate where the dependence between the criteria for selecting possible options is very high and determines the relationships between criteria. The fuzzy ANP process includes the following steps:

1. Modeling and structuring the problem : The problem should be clearly stated and broken down into a logical system, for example, a network. This structure can be obtained using the opinion of decision-makers and through methods such as brainstorming or other appropriate methods.
2. Pair-wise Comparison Matrixes: Establishing a pair-wise comparison of options (criteria) with the classical 1-9 hourly spectrum and construct a pair-wise comparison matrix using fuzzy triangular numbers (l, m. U) and a matrix as follows:

$$\tilde{A} = \begin{bmatrix} (a^l_{11}, a^m_{11}, a^u_{11}) & (a^l_{12}, a^m_{12}, a^u_{12}) & \cdots & (a^l_{1n}, a^m_{1n}, a^u_{1n}) \\ (a^l_{21}, a^m_{21}, a^u_{21}) & (a^l_{22}, a^m_{22}, a^u_{22}) & \cdots & (a^l_{2n}, a^m_{2n}, a^u_{2n}) \\ \vdots & \vdots & \vdots & \vdots \\ (a^l_{m1}, a^m_{m1}, a^u_{m1}) & (a^l_{m2}, a^m_{m2}, a^u_{m2}) & \cdots & (a^l_{mn}, a^m_{mn}, a^u_{mn}) \end{bmatrix}$$

$$\tilde{A} = \begin{bmatrix} (1,1,1) & (a^l_{12}, a^m_{12}, a^u_{12}) & \cdots & (a^l_{1n}, a^m_{1n}, a^u_{1n}) \\ \left(\frac{1}{a^l_{12}}, \frac{1}{a^m_{12}}, \frac{1}{a^u_{12}}\right) & (1,1,1) & \cdots & (a^l_{2n}, a^m_{2n}, a^u_{2n}) \\ \vdots & \vdots & \vdots & \vdots \\ \left(\frac{1}{a^l_{1n}}, \frac{1}{a^m_{1n}}, \frac{1}{a^u_{1n}}\right) & \left(\frac{1}{a^l_{2n}}, \frac{1}{a^m_{2n}}, \frac{1}{a^u_{2n}}\right) & \cdots & (1,1,1) \end{bmatrix}$$

Figure 2:

5 Super matrix

Logarithmic methods of least squares and Chang's developmental analysis method are used to obtain the weight of the indicators. In the following, the logarithm method of least squares is described.

The logarithmic method of least squares of fuzzy weights is presented below. The following steps were performed to calculate $\widetilde{W_1}$, $\widetilde{W_2}$ and the corresponding weight to obtain the weight of the indices according to the supermatrix $\widetilde{W}$, which is as follows:

$$\widetilde{W} = \begin{bmatrix} 0 & 0 \\ \widetilde{W_{21}} & \widetilde{W_{22}} \end{bmatrix}$$

In $\widetilde{W}$ matrix, $\widetilde{W_{21}}$ is the opinion matrix of the decision team regarding the pair-wise comparison of the ranking indicators concerning the primary goal. The matrix $\widetilde{W_{22}}$ is also calculated from the experts' opinions regarding the pair-wise comparisons of the other indicators and using the logarithm method of least squares to combine the criteria. The logarithmic method of least squares of fuzzy weights n and the n table are given in the following:

$$\widetilde{w_k} = (w_k^1, w_k^m, w_k^u), \qquad k = 1, 2, 3, \ldots, n$$

So that

$$w_k^s = \frac{\left[\prod_{j=1}^{n} a_{kj}^s\right]^{\frac{1}{n}}}{\left[\prod_{j=1}^{n} a_{kj}^m\right]^{\frac{1}{n}}}, \qquad s \in \{1, m, u\}$$

Then, $\widetilde{W_1}$ matric is calculated as $\widetilde{W_1} = \widetilde{W_{21}} * \widetilde{W_{21}}$ and obtained using the logarithmic method, the least squares of the fuzzy weight of each prioritization indicator.

6 Calculation

Various articles were used, and the factors were extracted to identify the factors. Weight limitation was applied in the model because the number of identified factors was high to localize the indicators and reduce inputs, as well as to determine their importance to each other and evaluate their validity. For this purpose, a questionnaire with 26 questions was designed qualitatively based on 5 points from extremely important to not-important, and 15 questionnaires were distributed among the first sample group and collected comprehensively and completely. Then, the scoring method was used to determine the most critical factors. The results of the weight order of criteria from 26 sub-factors were removed from the final conceptual model of the research, and finally, seven main indicators and 21 effective sub-indices were selected as essential and main factors for the final solution of the model. Then, the first research question was answered, which is identified in Table 3 as the most critical factor.

1. What are the indicators affecting the export industrial clusters in Gilan province?

Finally, the decision model was formed according to the following factors listed in Table 5.

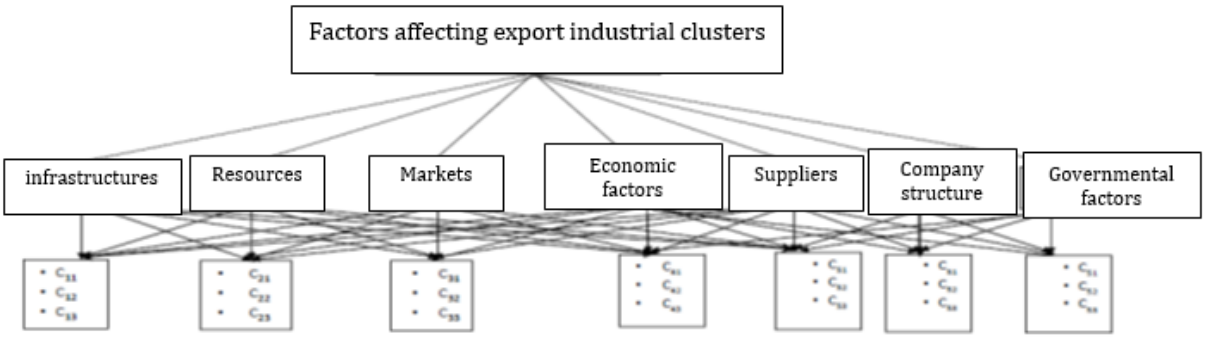

Figure 3: Research network structure

6.1 DEMATEL problem-solving

The sum of the elements of the columns and rows of the matrix are calculated for the main factors and sub-factors, named as (effective) and (influential) vectors. The calculations are given in Table 4 and Table 5:

Table 3: Factors and sub-factors affecting export industrial clusters

Main factors	Sub-factors	Abbreviations
Infrastructure C_1	Communication infrastructure	C_{11}
	Transportation infrastructure	C_{12}
	Local factories and workshops in the area	C_{13}
Recources C_2	Human resources	C_{21}
	Technology	C_{22}
	Capital	C_{23}
Markets C_3	Market perspective	C_{31}
	Geographical distance	C_{32}
	Demand	C_{33}
Economic factors C_4	Competitiveness	C_{41}
	Economic efficiency	C_{42}
	Value chain breadth	C_{43}
Suppliers C_5	Strong suppliers	C_{51}
	Cooperation with related industries	C_{52}
	Major activities of production workshops	C_{53}
Company structure C_6	Sales policies	C_{61}
	Ability to manage	C_{62}
	Competitive price	C_{63}
Governmental factors C_7	Rules	C_{71}
	Public sector investments	C_{72}
	Government incentive policies	C_{73}

Table 4: $\widetilde{R}, \widetilde{D}, \widetilde{R}+\widetilde{D}, \widetilde{R}-\widetilde{D}$ criteria values

Factors	$\widetilde{D}$	$\widetilde{R}$	$\widetilde{R}+\widetilde{D}$	$\widetilde{R}-\widetilde{D}$	Result
Infrastructures	1.714	1.125	2.839	0.589	Effective
Resources	1.264	1.557	2.821	-0.293	Impressive
Markets	1.413	1.35	2.763	0.063	Effective
Economic factors	1.477	1.198	2.675	0.279	Effective
Suppliers	1.061	2.015	3.076	-0.955	Impressive
Company structure	0.959	2.134	3.093	-1.174	Most Impressive
Govermental factor	2.048	0.558	2.606	1.49	Most effective

The sum of the elements of the columns and rows of the matrix are calculated for the main factors and sub-factors

Table 5: $\widetilde{R}, \widetilde{D}, \widetilde{R}+\widetilde{D}, \widetilde{R}-\widetilde{D}$ sub-criteria values

	Sub-Factors	$\widetilde{D}$	$\widetilde{R}$	$\widetilde{R}+\widetilde{D}$	$\widetilde{R}-\widetilde{D}$	Result
Infrastructures	Communication infrastructure	0.331	0.291	0.622	0.0401	Effective
	Transportation infrastructure	0.326	0.322	0.647	0.004	Effective
	Local factories and workshops in the area	0.299	0.343	0.641	-0.044	Impressive
Resources	Human resources	0.323	0.313	0.635	0.0097	Effective
	Technology	0.274	0.307	0.582	-0.033	Impressive
	Capital	0.359	0.336	0.694	0.023	Effective
Markets	Market perspective	0.228	0.207	0.435	0.0215	Effective
	Geographical distance	0.219	0.222	0.441	-0.004	Impressive
	Demand	0.193	0.211	0.405	-0.018	Impressive
Economic factors	Competitiveness	0.34	0.339	0.68	0.0011	Effective
	Economic efficiency	0.326	0.322	0.648	0.0034	Effective
	Value chain breadth	0.315	0.32	0.635	-0.005	Impressive
Suppliers	Strong suppliers	0.293	0.287	0.58	0.0062	Effective
	Cooperation with related industries	0.299	0.292	0.591	0.0075	Effective
	Major activities of production workshops	0.274	0.287	0.561	-0.014	Impressive
Company structure	Sales policies	0.3	0.287	0.587	0.013	Effective
	Ability to manage	0.272	0.24	0.512	0.0314	Effective
	Competitive price	0.228	0.272	0.499	-0.044	Impressive
Govermental factor	Rules	0.239	0.227	0.466	0.0121	Effective
	Public sector investments	0.22	0.228	0.448	-0.007	Impressive
	Government incentive policies	0.215	0.22	0.435	-0.005	Impressive

and named as effective and impressive as given in Table 4 and Table 5:

Figure 4 illustrates the significance of effectiveness and impressiveness between criteria. The horizontal and vertical axes of the chart are related to criteria and effectiveness, respectively. Therefore, the importance and effectiveness/impressiveness of the criteria, respectively, are the governmental factor, infrastructure, economic factors, market, resource, supplier, and company structure. The indicators with positive $\widetilde{R}-\widetilde{D}$ values in Table 6 show the definite effectiveness of these factors and negative $\widetilde{R}-\widetilde{D}$ value indicates the definite impressiveness of these factors over other factors. Therefore, the governmental factor (1.49) is the most effective, and the company structure (-1.174) is the most impressive factor among the main factors. In general, positive $\widetilde{R}-\widetilde{D}$ and negative $\widetilde{R}-\widetilde{D}$ are considered cause and effect, respectively, which responses to the second research question (How are the causal relationships (effectiveness/impressiveness) among the effective criteria on export industrial clusters in Gilan province?). Finally, the cause-and-effect relationships are plotted in a Cartesian coordinate system by drawing points with coordinates $\widetilde{R}+\widetilde{D}$ and $\widetilde{R}-\widetilde{D}$ based on the matrix. Accordingly, the cause-and-effect diagram and the network of factors are shown in Figure 4.

6.2 Weighting of factors by fuzzy analytic network process method

At this stage, the weighted supermatrix is calculated and then converges to the power of 7 to obtain the limit supermatrix using the T matrix to achieve the weight and priority of the factors. Finally, the weights of the factors and sub-factors are determined and obtained by biphasizing the weights by the center of gravity method (Table 6).

As shown in Table 6, the highest weight is related to the company structure factor with the first priority. In addition, sales policies gained the highest weight and the first priority in sub-factors. Competitive price, cooperation with related industries, strong suppliers, ability to manage, and major activities of production workshops were the second to sixth ranks, respectively, with approximately 48.12% of the total weight of the sub-factors, which shows the great importance of these sub-factors. Other factors also acquired the next priorities, as shown in Table 6. Figure 5 and 6 demonstrates the final priority of the main and sub-factors by the F.ANP method.

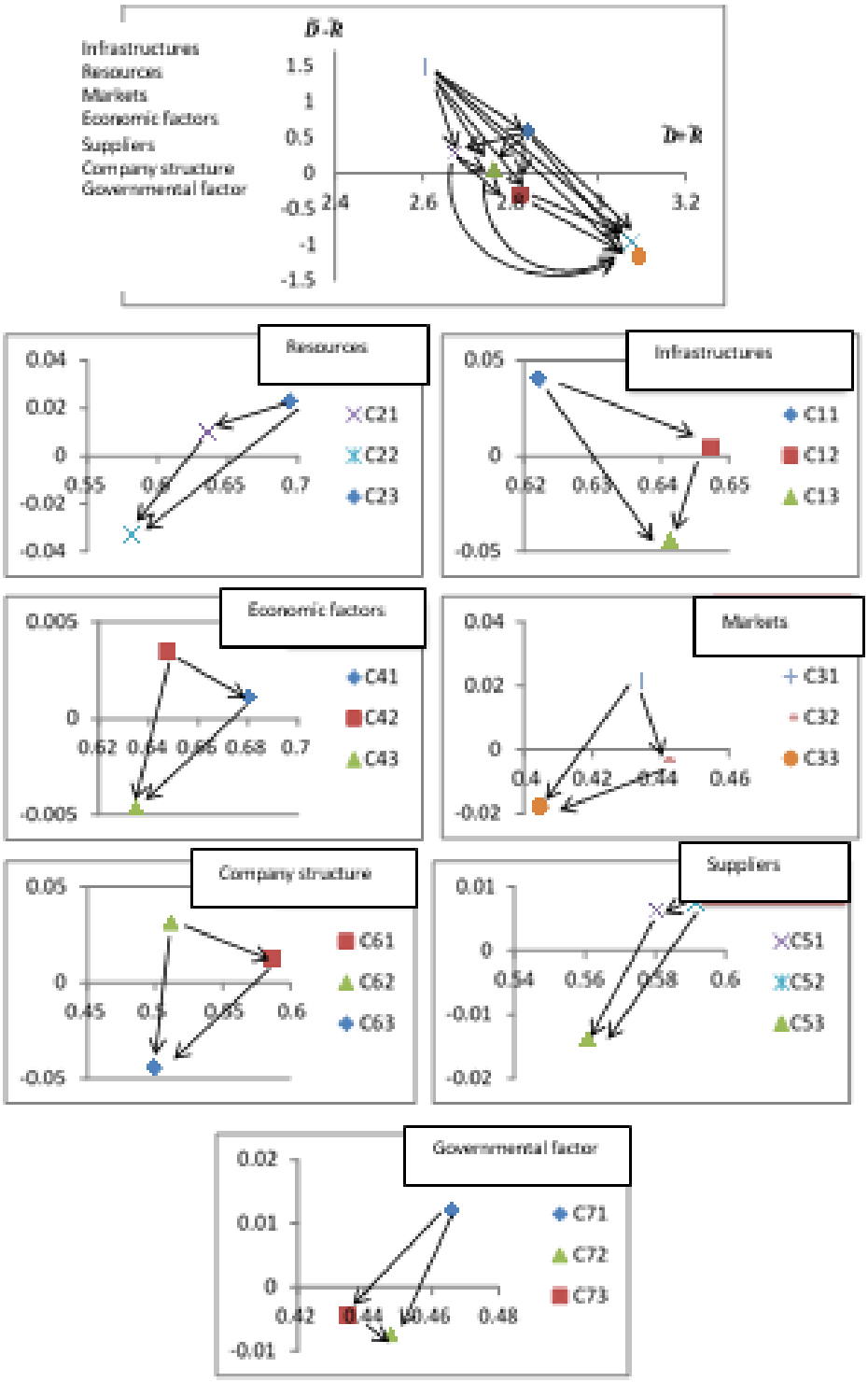

Figure 4: Relationship network between main criteria and sub-criteria

Table 6: Weight and priority of criteria and sub-criteria affecting the green supply chain

Weight and priority of the main factors		Sub-factor	code	Weight and priority of the sub-factors		Weight and priority of the sub-factors	
Infrastructures C_1	0.108 (5)	Communication	C_{11}	0.303	3	0.0327	18
		Transportation	C_{12}	0.327	2	0.0353	15
		Local factories and	C_{13}	0.37	1	0.04	12
Resources C_2	0.147 (3)	Human resources	C_{21}	0.405	2	0.0495	8
		Technology	C_{22}	0.361	3	0.0442	9
		Capital	C_{23}	0.438	1	0.0536	7
Markets C_3	0.122 (4)	Market perspective	C_{31}	0.343	2	0.042	11
		Geographical distance	C_{32}	0.344	1	0.0421	10
		Demand	C_{33}	0.313	3	0.0383	13
Economic factors C_4	0.102 (6)	Competitiveness	C_{41}	0.351	1	0.0359	14
		Economic efficiency	C_{42}	0.326	2	0.0334	16
		Value chain breadth	C_{43}	0.324	3	0.0332	17
Suppliers C_5	0.227 (2)	Strong suppliers	C_{51}	0.347	2	0.0786	4
		Cooperation with	C_{52}	0.348	1	0.0789	3
		Major activities of production workshops	C_{53}	0.306	3	0.0693	6
Company structure C_6	0.254 (1)	Sales policies	C_{61}	0.367	1	0.0934	1
		Ability to manage	C_{62}	0.276	3	0.0702	5
		Competitive price	C_{63}	0.357	2	0.0908	2
Governmental factors C_7	0.039 (7)	Rules	C_{71}	0.337	1	0.013	19
		Public sector	C_{72}	0.336	2	0.0129	20
		Government incentive	C_{73}	0.328	3	0.0126	21

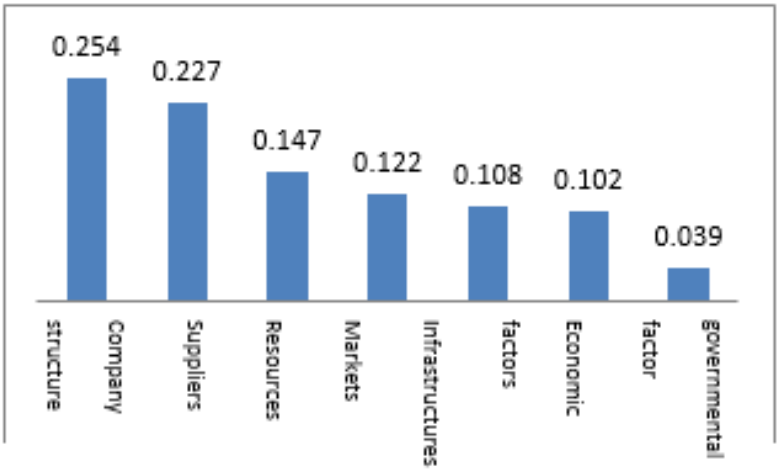

Figure 5: Relative priority of the main factors

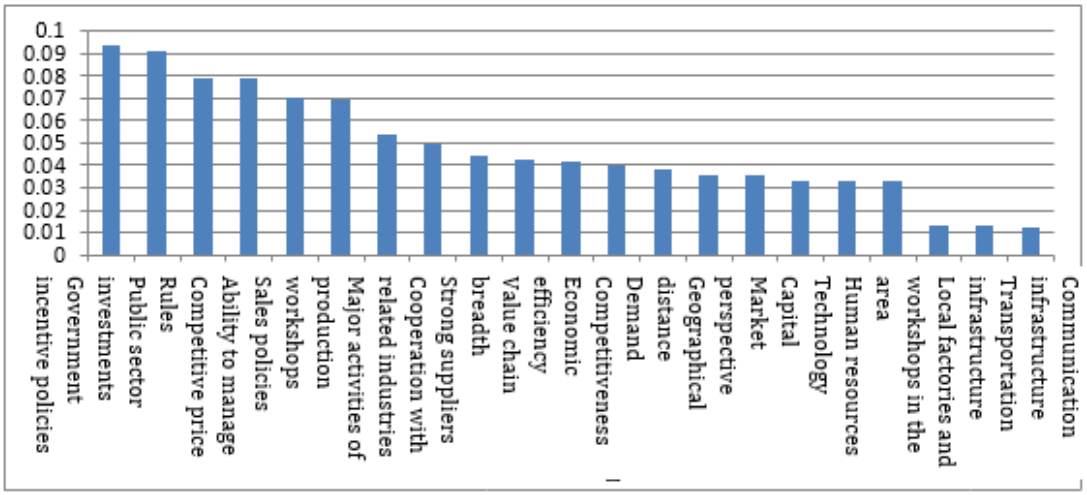

Figure 6: Final priority of sub-factors

7 Discussions

This study was first aimed to identify the factors affecting the export industrial clusters in Gilan Province. According to the studies and following the screening, 21 important factors were identified, the main criteria of which were infrastructure, markets, resources, economic factors, suppliers, and company structure. The study then aimed to determine the relationships and effects of factors on each other using the DEMATEL technique. According to this technique, company structure is the most effective factor affecting export industrial clusters in Gilan province as the main problem and bottleneck of improvement on export industrial clusters, which is solved by effective factors. The success or failure of export industrial clusters in Gilan province depends on this factor. Businesses in Gilan province must pay attention to export industry clusters such as factors of company structure to achieve productivity and competitive advantage. In addition, the governmental factor is the most effective in export industrial clusters as a vital criterion, which solves the problem and should be prioritized to improve the system. The governmental factor significantly affects industrial clusters in export industrial clusters by increasing efficiency and improving processes.

The third aim of the research was to calculate the relative weights of criteria and sub-criteria and determine their priority using the fuzzy analytic network process. The company structure with a weight of 0.254 is the most crucial export industrial cluster among the main factors based on experts' opinions. In other words, the company structure is one of the most critical factors in the industrial clusters of exports, and senior managers of the organization need

to pay close attention. The sales policy factor, with a final weight of 0.0349% of the total weights, gained the first priority among the sub-factors at the operational level. The improvement of export industrial clusters depends on the structure of the company, which always tries to play a role by improving sales policies in the organization. This study proposed some solutions according to the results. According to F.DEMATEL results, the company structure is the most effective factor in export industrial clusters, which should try to make the success of the study population with suggestions. The success or failure of the organization is to this criterion (the most affected), and this criterion's effect severity should be used to strengthen the system. Therefore, senior managers and decision-makers of export industrial clusters of Gilan province are suggested to try to increase and maintain their competitive position by improving sales policies, capability, management ability, and the competitive price. In addition, the governmental factor is the most effective factor in the industrial clusters of exports, which should try to make suggestions for the success of the studies company because the success or failure of the company is based on this criterion (the most effective) and the severity of the effect of this criterion should be used to strengthen the system. Therefore, senior managers and decision-makers of export industrial clusters of Gilan province are suggested to try to increase and maintain their competitive position by improving regulations, increasing public sector investment, and enhancing government incentive policies. According to the results of F.ANP, the company structure is the most important factor among the main criteria, and the sales policy as its sub-index significantly affects the export industrial clusters. Senior managers and decision-makers of export industrial clusters of Guilan province are suggested to pay attention to improving sales policies, increasing the competitiveness of the cost price, and ability to manage to lead the organization in this direction. Among the main criteria, the second most important is the suppliers, and the index of cooperation with industries related to export industrial clusters has a significant role as its sub-indicator. Therefore, senior managers and decision-making departments of export industrial clusters of Gilan province are suggested to pay attention to increasing strong cooperation with related industries, improving strong suppliers, and enhancing the major activities of production workshops to lead the organization in this direction. Resource gained the third rake of importance, and the capital index significantly affected the export industrial clusters among its sub-indicators. Therefore, senior managers and decision-makers of export industrial clusters of Gilan province are suggested to pay attention to improving capital, employ appropriate human resources, and make appropriate use of technology to help the organization to improve export industrial clusters. The fourth important factor is markets, and the geographical distance index has a vital role in export industrial clusters as its sub-index. Hence, senior managers and decision-makers of export industrial clusters of Gilan province are recommended to pay attention to such issues by reducing the geographical distance, improving the market perspective, and considering demands to help the organization improve industrial export clusters. The infrastructure and local factories and workshops in the region were the fifth main factor and its sub-index. Thus, the senior managers of the industrial export clusters of Gilan province are suggested to pay attention to such issues by increasing the number of local factories and workshops in the region, transportation infrastructure, and communication infrastructure to improve the industrial clusters of exports. Among the main factors, the sixth rank was related to economic factors, and the competitiveness index as its sub-index was effective. Therefore, senior managers and decision-makers of export industrial clusters of Gilan province are recommended to consider issues by increasing competitiveness, economic efficiency, and value chain to improve the industrial clusters. The least important factor was the governmental factor, and the regulation index was significant among its sub-indicators. Hence, senior managers and decision-makers in the export industry clusters of Gilan province are advised to improve regulations and increase public sector investment and government incentive policies to help the organization improve its export industry clusters.

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