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RESEARCH PAPER

Selection of Strategic Value Chain using Hybrid Entropy-TOPSIS-Fuzzy Approach

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ABSTRACT
Nowadays, it is very important to pay attention to the influential factors and economic and social drivers in developing countries, and identifying and evaluating the performance of Strategic value chains (SVCs) is in this direction. Evaluating local VCs and planning to upgrade them to the region and the world can be part of the development programs of each country. The correct selection of SVCs, considering the economic and competitive environment of the region, causes economic and social transformation. In this research, considering the development programs of Iran and especially Yazd province, the value-creating sectors of Yazd province were considered. After studying the upstream documents, the active VCs in the Yazd province were first extracted. Then, by reviewing the literature on the subject and asking for opinions from experts, the criteria for evaluating SVCs from the economic, social, and regional perspectives were determined. The Shannon entropy method was used to weight the evaluation criteria, and the fuzzy TOPSIS method was used to select the most effective VCs. From the literature review, documents, and field observations, 20 local VCs and 8 evaluation criteria were extracted and approved by experts. The study results revealed that the evaluation criteria of "High job creation" and "Positive effect on gross domestic product (GDP)" had the highest weights, and "Tourism and handicrafts", "Textile and clothing", "Commercial logistics and transportation", and "Non-metallic minerals" had the highest impacts in Yazd Province, according to the evaluation criteria known as SVCs. Moreover, a sensitivity analysis was performed to determine the stability and robustness of the proposed approach by changing the weights of the desired criteria.

KEYWORDS: *Value chain; Performance evaluation; Shannon's entropy method; Fuzzy TOPSIS method.*

1. Introduction

A novel trend has arisen in the exchange of information and communication, which is appreciated in the Information Age. Upon entering the business world and being exploited in terms of competition, this trend has also transcended national and regional boundaries and grown into a modern, global form. Under these conditions, scientific and technological advancements, along with higher rates of production with higher quality and diversity, far beyond the market and customer demand, have progressively made competition much more intense, to the extent that all companies now make every effort to maintain their survival and stay in touch with up-to-date markets and customers. Customers and their satisfaction in the business world have accordingly become of utmost importance, thereby shifting producers' mindset from products to customers in a way that customer satisfaction and loyalty have been the major goals to meet. Marketing specialists have further considered gaining a competitive advantage, possibly through tools such as value chain (VC) models, as the main strategy for most organizations and companies to fulfill their objectives.

In their development approaches, in particular economic development plans, governments can support businesses' development and growth, mainly by creating infrastructure and giving permissions. Despite desirable encouragement in this line, most businesses still face many problems related to skills development, marketing, product design, financing, and so on. To address such weaknesses, it is thus vital to implement a series of coherent and efficient programs that help establish a connection between the backward and forward linkages in a business from a chain perspective. This economic development approach consequently creates a network at the level of businesses in the form of VC, as a strategic tool representing the set of activities practiced to create value, also called value activities [1]. Besides, VCs contain activities that help create value-added in organizations and companies, so

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they can take steps toward facilitating production and supply, and then make prices more competitive [2]. The concept of VC was first proposed by Porter in 1985. He stated that a company could be composed of a set of activities for the design, production, marketing, delivery, and support of its products. The integration of such activities could lead to company profitability and VC creation for customers [3]. The main strength of the VC approach is its consideration of a set of practical activities for designing, producing, marketing, presenting, and supporting products or services in businesses [4].

As government resources to support businesses are often limited, those whose chains create the highest value typically receive much more support. Investors also show a preference for investing capital in chains with the highest value and return on investment (ROI). Considering this, one of the major challenges faced by investors, supporting organizations, policymakers, and governments is to determine the businesses that create the highest value based on national and regional conditions. To plan for the development, expansion, and promotion of VCs, it is thus of utmost importance to devote much attention to the most effective ones in local and regional ecosystems; in other words, VCs are considered significant in a region. In this way, a major concern is to find such chains. Evaluating effective VCs correctly based on specific environmental conditions makes it possible to accelerate economic growth and regional development regarding the potential and positive impacts of businesses. Notably, some VCs have greater potential for ROI and economic benefits than others.

VC development (VCD) projects mostly necessitate spending time and money. Encouraging as many industry owners as possible to invest and provide scientific and sound guidance for supporting organizations, principally governments, various criteria, including multi-criteria decision-making (MCDM) issues, should thus be taken into account in evaluating SVCs. As a result, industrial owners, policy-makers, and planners are assisted in making the best decisions. Against this background, the present study was an attempt to help choose the most effective VCs after identifying the evaluation criteria for this purpose and the decision alternatives or the proposed VCs, and then ranking them concerning the importance of the given criteria by different methods.

The novelty of this study can be summarized as follows:

- Listing businesses that run consistently with the VC approach in local economies
- Developing evaluation criteria for business VCs with a focus on value added and job creation
- Exploiting the MCDM approach to evaluate and select an effective VC in Yazd Province, Iran

Among the main contributions of this study were identifying VCs using a comprehensive approach, including supply, production, and sales; presenting unique evaluation criteria; and recruiting a hybrid fuzzy entropy-technique for order of preference by similarity to ideal solution (TOPSIS) approach to select the best VCs, which had been less studied in previous research.

The remainder of this paper is structured as follows. Section 2 presents a review of the relevant literature. In Section 3, the methodology of the research is presented. Section 4 presents numerical examples of data analysis related to identifying SVCs for the Yazd Province extracted and ranked. Section 5 presents the discussion. The managerial and practical implications are presented in Section 6. Finally, the concluding remarks and suggestions for future work are given in Section 7.

2. Literature Review

The concept of VC was first proposed by Porter in 1985 [5]. In 2003, he decided that VCs could help organizations analyze their specific activities to create value for customers and gain a competitive advantage. In his words, value creation for each organization or company was the main objective of the strategy. The VC framework is thus an approach to decode business functions into strategic activities through which value is added to products and services in a business or industry [5]. VC analysis is typically performed to understand cost and resource consumption behaviors [6]. Strategic analysts also analyze the VCs of businesses or industries to understand their weaknesses, discover and evaluate development opportunities, improve profit margins, and gain a deeper understanding of suppliers, customers, and competitors [7]. In today's competitive world, the need to secure values to receive stakeholder support is compelling industries to examine the tools by which values are created or destroyed.

To choose VCs, Schneemann (2015) proposed several strategies by integrating social, economic, environmental, and institutional criteria. He found that the VCD approach had the greatest impact through interventions based on specific development goals. He then introduced VC selection from a comprehensive and structured view. These criteria could merge the mentioned dimensions of VC with sustainable development. Upon connecting these criteria, he outlined eight steps for selecting and evaluating VCs in the private sector development plan in Yemen in 2014, containing two sub-sectors, namely, furniture for institutions, e.g., schools, offices, and small health stations, and waste recycling, which were finally compared [8]. Narula and Bhattacharyya (2017), reflecting on VC development in India through off-grid electricity interventions, also indicated that no access to electricity for production activities was a barrier to sustainable rural development. They conducted interviews, held focus group meetings, and considered stakeholder engagement in a cluster of five remote off-grid villages, and developed a new VC framework in which production activities could be supported through electrification, thereby resulting in higher income, improved livelihoods, and better quality [9]. In addition, Mertens et al. (2019) studied the development of bioeconomy VC by dealing with nontechnical challenges and shed light on the development process of corn VC in two regions in Canada and Belgium, utilizing an integrated analytical framework, and compared the results with the related literature within seven measures [10]. Havardi-Burger et al. (2021) also presented a framework for evaluating the sustainable VC of potted flowering plants in Germany and pointed out that the structure of this chain was different from that of other agricultural products. This challenge was examined from environmental and socioeconomic perspectives. After adjusting some indicators, they further selected some based on VC, cultivation, production, and distribution, as well as geographical regions and stakeholders. They concluded that the profitability of the ornamental sector, which was more vulnerable, was facing low margins and high uncertainty. In addition, some guiding principles have been proposed for improving VC performance [11]. In this regard, Wubet et al. (2022) analyzed the VC of potatoes in Ethiopia. Considering the importance of food security in developing countries, the researchers employed descriptive-inferential econometric analysis methods to investigate the market and identify the key actors. The main VC of potatoes in the study area was then discussed, and the results of the VC analysis, the variables shaping the decisions to participate in the market, the amount of supply to the market, and the main limitations of production and commercialization of this product were then delineated [12]. Deka and Goswami (2022) similarly examined the development of sustainable VC for tea smallholders in India, participating in the processing and marketing of tea for organic cultivation. This enabled the development of this VC. They also suggested managing smallholders better, building trust, creating value networks through strategic cooperation, empowering farmers, and promoting sustainability in the tea production sector as the main strategies [13]. Nahar et al. (2022) used questionnaires to comparably evaluate the factors and limitations of VC development in dairy products in Bangladesh. The multiple regression models for the factors influencing the value-added of the selected products further demonstrated that gender, educational attainment, purchase price and selling price had the most significant effects on the value-added of the VC for processed dairy products. Likewise, insufficient capital and credit facilities, lack of storage facilities, lack of processing centers, and transportation issues are some of the limitations facing market operators [14]. Songsermsawas et al. (2023) then inspected the development of agricultural VC based on ethnicity and gender in Nepal. They reduced poverty among small-scale producers by boosting agricultural productivity and reducing costs while placing greater emphasis on minority producers and women. The study established that productivity gaps related to ethnicity and gender could be bridged, but they could not be eradicated. Moreover, land tenure security programs with specific targets could help vulnerable producers with reduced productivity differences [15]. Moretti et al. (2023) reflected on the contribution of VCs to the resilient and sustainable development in the mountainous regions of Europe by examining human and natural system chains along with their interactions. They found that local development strategies require a more systemic, integrated, and asset-based approach to value creation. In their study, the authors further proposed a new comparative framework to describe the

contribution of VCs to flexible and sustainable socio-ecological systems in mountainous regions. The framework presented for this purpose highlighted the role of VCs to better balance natural resource protection and sustainable socio-economic development in rural and remote European regions [16]. Mehrez et al. (2023) correspondingly suggested some marketing strategies for developing SVCs for Khawlani coffee in Saudi Arabia. The researchers collected data through in-depth interviews with coffee farmers in six mountainous regions of the country, analyzed the data using content analysis, and identified the main components. Finally, they proposed a series of marketing strategies for stakeholders to encourage strategic investment in VCD [17].

2.1. MCDM techniques

Decision-making is undoubtedly one of the primary skills in human life, as various problems often appear that unavoidably force people to make a decision. Individual and group decision-making generally has conflicting goals. Making logical decisions and finding optimal solutions for real problems, which always depend on numerous decision-making indicators, have accordingly led to the development of MCDM approaches, which have had a good place among decision-making strategies despite being presented for a few decades [18]. The use of computers and the advancement of information technology (IT) have greatly augmented the efficiency of such models and have made MCDM-based models a growing tool for dealing with complex decision-making issues in various fields, such as management, social sciences, economics, energy, supply chain, quality assurance, information and communication technology (ICT), transportation, etc. [19-21].

In general, MCDM consists of different steps, viz., identifying objectives, setting priorities, evaluating alternatives, and choosing the best [22]. To decide using the proposed MCDM techniques, the first step is to determine the number of indicators and criteria for a given problem. The next step was to collect data to reflect the decision-makers' opinions. Then, different alternatives are established that can help decision-makers achieve their goals. As a final step, there is a need to select the best method for evaluating and prioritizing desired alternatives. In recent years, various MCDM techniques have been developed to resolve the existing problems. Some of these methods include the following: analytical network process (ANP) [23], analytic hierarchy process (AHP) [24, 25], preference ranking organization method for enrichment evaluations (PROMETHEE) [26, 27], elimination and choice expressing reality (ELECTRE) [28], the order of preference by similarity to an ideal solution (TOPSIS) [29-32], and simple additive weighting (SAW) [33, 34].

In many studies, the TOPSIS method has been reported as a flexible tool for solving the MCDM problems of distance-based uncertainty. The reason for its preeminence is the small number of calculations, ease in weighting the criteria, and ease in changing the weights. In this regard, Thor et al. (2013) [35], Junior et al. (2014) [25], and Wang et al. (2022) [21] also favored the TOPSIS method because of its high structural compatibility, ease of large data analysis, and simplicity of calculations compared to simple additive weighting (SAW), analytic hierarchy process (AHP), and elimination and choice translating reality (ELECTRE)-based methods [36]. Elsayed et al. (2017) further considered the TOPSIS method to be much more suitable as it could measure the relative performance of each alternative and thus had computational efficiency [37]. Additionally, Alao et al. (2020) reported the TOPSIS techniques as effective MCDM-based ones, thanks to their simplicity and comprehensibility [23]. Based on these advantages, the TOPSIS method was implemented in this study.

In the MCDM models, the criteria should first be weighted to evaluate their relative importance to the alternatives. The values are often between 0 and 1 [23]. Several techniques have been developed to determine the weighting of the criteria, including entropy, standard deviation (SD), weighted average, analysis of variance [38], and correlation [39]. Among them, Shannon's entropy method has been extensively applied in numerous studies to weight such criteria [23]. Therefore, this was practiced in this study. MCDM techniques are typically based on decision-makers' judgments about alternatives, signifying the relative importance of the criteria to alternatives, which are typically communicated through verbal expressions and then converted into quantitative values. Fuzzy logic has also been observed to address the uncertainty in the qualitative attributes of given verbal expressions [23]. In many studies in which the data have been in the form of verbal variables, the TOPSIS technique combined with

the fuzzy logic has been accordingly exploited [40]. Based on the aforementioned reasons and research objectives, i.e., selecting the best SVCs with the highest impact on the local economy, the hybrid fuzzy entropy-TOPSIS approach was employed. As an illustration, there have been some applications of the combined form of the entropy and TOPSIS methods in the related literature. In this regard, Zhao (2009) used the entropy method together with TOPSIS to evaluate the knowledge of VC management and its performance in some companies [41]. Aghajani and Ahmadpour (2011) further ranked chain suppliers in Iran's automobile industry using the fuzzy TOPSIS method [42]. In addition, Zeng (2011) presented a model to determine the governing structure of global VC based on TOPSIS [43]. Mousaei and Hatefi (2015) also introduced a decision-support system (DSS) for selecting the best fuel for development in natural gas VC [44]. In the same study, Wood (2016) employed the hybrid fuzzy TOPSIS-entropy approach to choose a supplier for the development of oil industry facilities [36]. Besides, Liu et al. (2019) evaluated the sustainable performance of suppliers in an agrifood VC, using a fuzzy decision-making tool [45]. Moreover, Cao and Xu (2022) implemented the fuzzy TOPSIS and entropy method for optimal decision-making in large-scale project investment [19]. Furthermore, an et al. (2023) evaluated the development of renewable energy in the countries in the Belt and Road Initiative in a study using the TOPSIS and entropy combined [46].

3. Methods

Given that the study results could be of importance for industrial owners and economic policy-makers to learn much more about leading VCs, an applied research design was adopted. In terms of the research philosophy, seeking to develop concepts in a specific field, especially knowledge of VC evaluation criteria, this study was of the constructionist type. Thus, the research objectives were met via descriptive-analytical methods. The data were also collected in the form of a library study, reviewing documents and related literature, and obtaining expert opinions. The study setting was Yazd Province, Iran, with particularly active SVCs in this region. Upon analyzing the upstream documents of Yazd Province and conducting a field survey of the active economic sectors, the value-creating and influential sectors in its economy were extracted, and those with VC capabilities were identified in the first phase. Then, the evaluation criteria for the VCs were determined in the second phase based on previous research and expert opinions. In the third phase, Shannon's entropy method was used to weight the criteria, and the fuzzy TOPSIS method was employed to identify and rank the most effective value-creating SVCs. The reason for choosing the combined method of fuzzy TOPSIS and entropy in this study is that, based on the materials stated in the literature section, the TOPSIS method is superior to other MCDM methods due to its computational efficiency and desirable ability to measure the relative performance of each option. Among the criteria weighting methods, the entropy method is simpler and has been used more in previous similar studies. Usually, the relative importance of a criterion to the options is expressed through qualitative characteristics or verbal expressions. In practice, these qualitative characteristics must be converted to quantitative ones. The subjective opinions and judgments expressed by experts often have ambiguity and uncertainty, and this uncertainty can be used by using a fuzzy scale and converting it into a numerical form to express these subjective characteristics. Therefore, in this study, considering that the data are in the form of verbal variables, the TOPSIS technique is combined with fuzzy logic. The experts were selected using non-probability, non-random, and purposeful sampling from those with at least five years of professional experience in economic and industrial fields and a relevant bachelor's degree. Figure 1 shows the research process.

3.1. Fuzzy sets and fuzzy numbers

Of note, human thoughts and perceptions are often associated with uncertainty, which often affects their decisions. An effective and efficient strategy to handle uncertainty is to use the fuzzy-set theory, which was first presented by Zadeh [47]. It is a theory for action under the conditions of uncertainty, which can mathematically transform many ambiguous concepts, variables, and systems and even pave the ground for reasoning, inference, and decision-making [48]. As verbal variables are not clearly expressed and entail some ambiguity, each verbal element is typically defined to a related fuzzy number that helps specify the meaning of the verbal expression, which then facilitates the decision-making process [49].

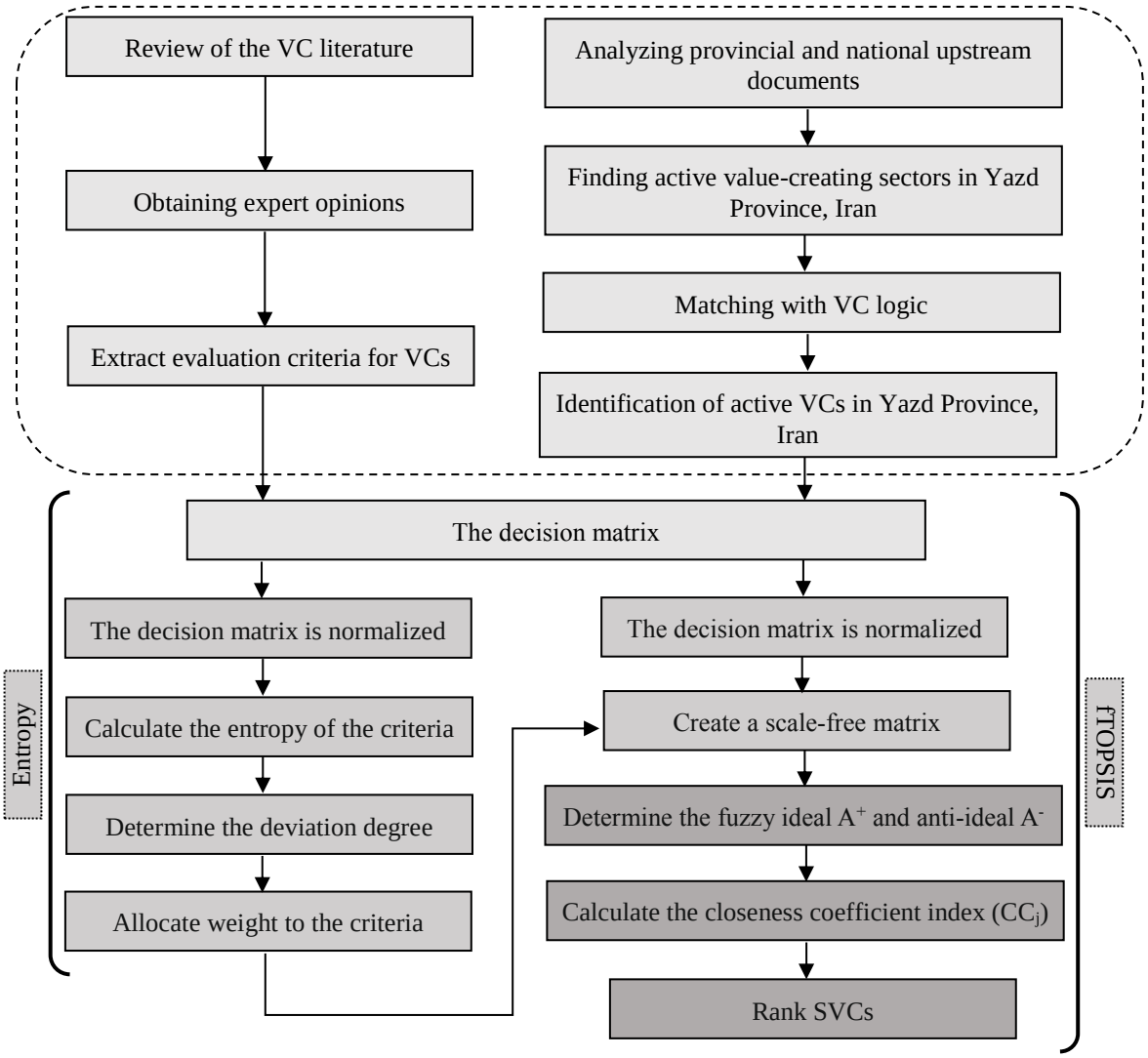

Fig.1. Research process

The development of fuzzy sets and the definition of their membership functions (MFs) depend on the context and scope of the application. The MF with triangular fuzzy numbers is thus the most widely used fuzzy set theory in the literature. This function performs accessible calculations and can display and process information in fuzzy situations [50]. Therefore, the MF with triangular fuzzy numbers was employed in this study.

Triangular fuzzy numbers can be defined as a triplet $\widetilde{M}$= (a, b, c). Parameters a, b, and c. respectively, indicate the smallest, most promising, and largest possible values that describe a fuzzy event. The triangular fuzzy number M is shown in Figure 2 [51].

A fuzzy number $\widetilde{M}$ on R is a TFN if its membership functions μ(y): R→[0, 1] is equal to Eq. (1):

$$\mu_{\widetilde{M}}(y) = \begin{cases} \frac{y-a}{b-a}. & a \le y \le b \\ \frac{c-y}{c-b}. & b \le y \le c \\ 0. & \text{otherwise} \end{cases} \quad (1)$$

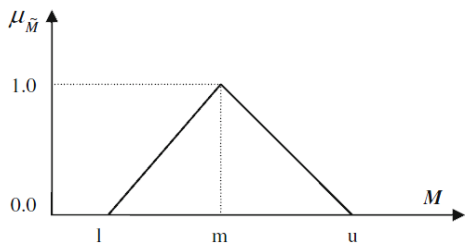

Fig.2. Triangular fuzzy number

3.2. Shannon's entropy weighting method

The entropy weight method was first proposed by Shannon and Weaver in 1974 [52]. The concept of entropy can be expressed as a criterion

for the degree of uncertainty represented by a distinct probability distribution [53]. The main idea behind this method is that the greater the dispersion in the values of an index, the more important that index is [54]. Thus, the entropy method proceeds in the following five steps:

Step 1: Create a decision matrix. This matrix decision contains m alternatives and K criteria; thus, R alternatives were evaluated using the K criteria.

Step 2: The decision matrix (In Step 1) was normalized based on Eq. 2.

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad (2)$$

Step 3: The entropy of the information was defined according to Eq. 3.

$$E_j = -K\sum_{i=1}^{R} p_{ij}\mathrm{Ln}(p_{ij}). \quad K = \frac{1}{\mathrm{Ln}(m)} \quad (3)$$

Step 4: The uncertainty or degree of deviation (dj) was determined according to Eq. 4.

$$d_j = 1 - E_j \quad (4)$$

Step 5: The weight of each criterion (W_j) was determined using Eq. 5.

$$W_j = \frac{d_j}{\sum_{i=1}^{n} d_j} \quad (5)$$

3.3. Fuzzy TOPSIS method

The TOPSIS method, which was first introduced by Huang and Yun (1981), is an MCDM-based technique that has been used to calculate some points and rank alternatives in decision-making problems [55]. The foundation is to choose alternatives that are least distant from the positive ideal solution (PIS) and most distant from the negative ideal solution (NIS). Of note, PIS helps maximize and minimize the cost criteria, whereas NIS boosts and reduces the cost criteria [56]. The developed fuzzy TOPSIS technique also facilitates the expression of the weights of the criteria and the scores of the alternatives using verbal variables represented by fuzzy numbers. It is appropriate and proper to solve group decision-making problems in a fuzzy background, whose phases are described as follows:

Step 1: Determine the weighting of the evaluation criteria (the weights of the criteria are calculated using the entropy method)

Step 2: Construct a fuzzy performance/decision matrix (choose the appropriate linguistic variables for the alternatives for the criteria).

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_1 & \cdots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \end{array} \quad i=1,2,\ldots,m;$$

$$j=1,2,\ldots,n; \quad \tilde{x}_{ij} = \frac{\sum \tilde{x}_{ij}^{(k)}}{k} \quad (6)$$

Where $\tilde{x}_{ij}^{k}$ is the performance rating of alternative A_i relative to criterion C_j evaluated by the kth expert, and $\tilde{x}_{ij}^{(k)} = (l_{ij}^{(k)}.m_{ij}^{(k)}.u_{ij}^{(k)})$.

Step 3: Normalize fuzzy-decision matrix. The normalized fuzzy-decision matrix is denoted by $\tilde{R}$ is shown as the following formula:

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n} \quad i = 1.2.\ldots.m; \quad j = 1.2.\ldots.n \quad (7)$$

Then, the normalization process can be performed using the following formula:

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{u_j^+}.\frac{m_{ij}}{u_j^+}.\frac{u_{ij}}{u_j^+}\right); \; u_j^+ = \max_i\{u_{ij}|i = 1.2.\ldots.m\}$$

for benefit criteria (8)

$$\tilde{r}_{ij} = \left(\frac{l_j^-}{u_{ij}}.\frac{l_j^-}{m_{ij}}.\frac{l_j^-}{l_{ij}}\right); \; l_j^- = \min\{l_{ij}|i = 1.2.\ldots.m\}$$

for cost criteria (9)

The normalized $\tilde{r}_{ij}$ is still a triangular fuzzy number. The weighted fuzzy normalized decision matrix is represented by the following matrix$\tilde{V}$:

$$\tilde{V} = [\tilde{v}_{ij}]_{mn}. i = 1.2.\ldots.m; \; j = 1.2.\ldots.n$$

Where $\tilde{v}_{ij} = \tilde{x}_{ij} * w_i$ (10)

Step 4: Identify the positive ideal (A^+) and negative ideal (A^-) solutions. The fuzzy positive-ideal solution (FPIS, A^+) and the fuzzy negative-ideal solution (FNIS, A^-) are shown in the following equations:

$$A^+ = \{\tilde{v}_1^+.\tilde{v}_2^+.\ldots.\tilde{v}_i^+\} = \left\{\left(\max_j v_{ij}\middle|i\epsilon I'\right).\times \left(\min_j v_{ij}\middle|i\epsilon I''\right)\right\}. i = 1.2.\ldots.n. \quad j = 1.2.\ldots.m \quad (11)$$

$$A^- = \{\tilde{v}_1^-.\tilde{v}_2^-.\ldots.\tilde{v}_i^-\} = \left\{\left(\min_j v_{ij}\middle|i\epsilon I'\right).\times \left(\max_j v_{ij}\middle|i\epsilon I''\right)\right\}. i = 1.2.\ldots.n \; j = 1.2.\ldots.m \quad (12)$$

Where $I'$is associated with the benefit criteria and I'' is associated with the cost criteria.

Step 5: Calculate the distance between each alternative from A^+ and A^- using the following equations:

$$D_j^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}.\tilde{v}_i^+), \quad j = 1.2.\ldots.m \quad (13)$$

$$D_j^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}.\tilde{v}_i^-), \quad j = 1.2.\ldots.m \quad (14)$$

Step 6: Calculate similarities to the ideal solution.

$$CC_j = \frac{D_j^-}{D_j^+ + D_j^-}, \quad j = 1.2.\ldots.m \quad (15)$$

Step 7: Rank preference order. Choose an alternative with maximum CC_j^* or rank alternatives according to CC_j^* in descending order.

4. Numerical Examples

In this study, the opinions of 12 experts were

obtained, of whom four individuals were experts from governing bodies and policy-makers involved in economic development organizations, three people were from economic development facilitator divisions, three cases were economic activists, and two experts were faculty members in the economics departments of universities. Based on the study of upstream documents and field observations of the VCs in Yazd Province, Iran, the related literature, and expert opinions, the evaluation criteria for the VCs were extracted, and the most effective ones in accordance with their importance were ranked using the MCDM method. Table 1 shows the professional background and expertise of each expert.

In summary, expert opinions were tapped to identify the sectors with the greatest value creation in the local economy of Yazd Province, Iran, introduce the VCs, extract the evaluation criteria for the VCs, and complete the decision matrix in line with the verbal expressions and weights to the given criteria. In this study, verbal variables were recruited to logically express situations that were difficult to define. Table 2 outlines the verbal variables used to rank alternatives based on the triangular fuzzy numbers.

The research steps were as follows:

Step 1: Identify VCs

Based on an analysis of the upstream documents of Yazd Province, Iran, and the economically active sectors in this region, 40 sectors with the highest value creation were initially identified. After examining and matching each sector with the chain logic and the maximum activities, the backward and forward linkages of the active chains were identified. Finally, 20 VCs were included following several further investigations, monitoring, and the elicitation of expert opinions. The active VCs in Yazd Province, Iran, are listed in Table 3.

Step 2: Determine the evaluation criteria for the SVCs

To identify the evaluation criteria in several stages of monitoring, local and national economic development documents, previous research, and expert opinion were used. First, by carefully studying the upstream documents, economic requirements, and regional and national development goals were considered. In the next step, to complete the development requirements extracted from the documents, the literature on the subject was reviewed and a list of appropriate and key criteria was extracted for evaluating VCs with an approach to influencing the economic and social ecosystem at the regional level. At this stage, 12 initial criteria were identified. Then, these criteria were provided to the experts and they were asked to review their importance and the effectiveness of these criteria in evaluating local VCs with respect to the economic and social capacities of Yazd province. After several meetings and explaining each of the criteria to the experts, finally, after summing up the experts' opinions, 8 criteria were identified as key evaluation criteria, which are listed in Table 4.

Step 3: Creating a decision matrix

To evaluate the active VCs in Yazd Province, Iran, as mentioned earlier, the opinions of 12 experts were obtained based on the framework presented in Table 1. Upon completing the initial decision matrices by all the experts, the verbal expressions were converted into triangular fuzzy numbers, and the average of the fuzzy numbers was calculated.

Tab.1. Professional background and expertise of each expert

Row	Job	Organization	Expertise	Degree
1	Faculty member	University	Industrial Engineering	PHD
2	Faculty member	University	Economy	PHD
3	Director of Investment and Employment Office	Governorship	Economy	PHD
4	Investment and employment expert	Labor Office	Management	PHD
5	Regional Development Expert	Management and Planning Organization	Economy	PHD
6	Industrial Development Expert	Industry Organization	Industrial Management	PHD
7	Business expert	Chamber of Commerce	Statistics	Master's
8	Export Expert	Chamber of Industry	Industrial Engineering	Master's
9	Employment Expert	Chamber of Cooperative	Public Administration	Bachelor's
10	Managing Director	Private sector	Electrical Engineering	Bachelor's
11	Board Member	Private sector	Industrial Management	Master's
12	Trading Company Manager	Private sector	Economics	PHD

Tab.2. Linguistic variables and triangular fuzzy numbers

Linguistic variables	TFN
Very low (VL)	(0,0.1,0.3)
Low (L)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
High (H)	(0.5,0.7,0.9)
Very high (VH)	(0.7,0.9,1)

Tab.3. Active VCs in Yazd Province, Iran

Code	Alternatives (VCs)
ALT1	Mining and metals industries
ALT2	Textiles and clothing
ALT3	Non-metallic minerals
ALT4	Tourism and handicrafts
ALT5	Wire and cable manufacturing
ALT6	Production of silicon
ALT7	Commercial logistics and transportation
ALT8	Pomegranate production
ALT9	Pistachio production
ALT10	Camel farming
ALT11	Ostrich farming
ALT12	Broiler and meat chicken farming
ALT13	Quail farming
ALT14	Tilapia farming
ALT15	Honey production
ALT16	Greenhouse products
ALT17	Saffron production
ALT18	Light and heavy livestock farming
ALT19	Sesame industry
ALT20	Traditional sweets

The final decision matrix was then calculated. Table 5 presents the decision matrix used in this study.

Step 4: Weighting criteria

In line with the research method, the desired criteria were weighted using Shannon's entropy method. After calculating the fuzzy set values of the expert opinions, the fuzzy data acquired through the center of area (CoA) fuzzification method were converted into definite data according to Eq. 16 [57], and the obtained value was then called the best non-fuzzy performance (BNP) [58].

$$X_{ij} = \frac{[(u_{ij}-l_{ij})+(m_{ij}-l_{ij})]}{3} + l_{ij} \quad (16)$$

The decision matrix based on the entropy-based calculations is presented in Table 6. Implementing the entropy method led to obtaining the weights of the criteria and their rankings based on their importance, as shown in the last rows of Table 6. Based on Table 6, it is clear that the criteria "High job creation" and "Positive effect on GDP" have the highest weight, and the criteria "Possibility of productivity" and "Export and market-orientedness" have the lowest weight for selecting SVCs in Yazd province. The priority order of the performance evaluation criteria of the active SVCs in this context, investigated in this study, was as follows.

C2>C8>C3>C5>C4>C1>C7>C6

The above prioritization, which shows the importance of the criteria for evaluating SVCs, is interpreted as follows: the most important goal of developing SVCs is to provide employment opportunities and create new job opportunities. In other words, it is a highly important activity category whose support and strengthening lead to job creation and the elimination of unemployment in the targeted society. The second important criterion in the above prioritization is "positive impact on GDP", which means that the development of SVCs in that activity category causes GDP to grow positively compared to previous years in the region and, consequently, at the national level. This criterion is important in this respect that a category is selected as a SVC that changes GDP and leads to economic development. The third criterion, "high economic value", has been determined for evaluating SVCs. In other words, an activity category should be selected as a SVC that has the highest economic added value compared to other categories, and focusing on each link in its development leads to value creation. Other criteria can be interpreted similarly.

Tab.4. Evaluation criteria for SVCs

Code	Criteria	Description
C1	Competitive advantage in the Yazd Province, Iran	VCD should be aligned with the region's competitive advantages.
C2	High job creation	VCD will lead to job creation in the region.
C3	High economic value	VCD creates added economic value.
C4	Internal capabilities	Governance and the government play a prominent role in VCD.
C5	Reliance on natural resources	VCD should not depend on the consumption of the region's natural resources.
C6	Possibility of productivity	VCD is possible through productivity improvements.
C7	Export- and market-orientedness	VCD leads to export development and market development.
C8	Positive effect on GDP	VCD leads to GDP growth.

Tab.5. The fuzzy decision matrix

Alternatives	Criteria																							
	C1			C2			C3			C4			C5			C6			C7			C8		
ALT1	0.58	0.78	0.94	0.42	0.62	0.82	0.7	0.9	1	0.5	0.7	0.86	0.04	0.18	0.38	0.54	0.74	0.9	0.54	0.74	0.9	0.62	0.82	0.96
ALT2	0.66	0.86	0.98	0.62	0.82	0.96	0.58	0.78	0.94	0.7	0.9	1	0.66	0.86	0.98	0.5	0.7	0.88	0.58	0.78	0.94	0.46	0.66	0.86
ALT3	0.62	0.82	0.96	0.46	0.66	0.86	0.46	0.66	0.84	0.42	0.62	0.82	0.22	0.42	0.62	0.7	0.9	1	0.7	0.9	1	0.62	0.82	0.96
ALT4	0.7	0.9	1	0.66	0.86	0.98	0.5	0.7	0.9	0.66	0.86	0.98	0.7	0.9	1	0.46	0.66	0.86	0.58	0.78	0.94	0.58	0.78	0.94
ALT5	0.5	0.7	0.9	0.06	0.22	0.42	0.14	0.34	0.54	0.28	0.46	0.66	0.3	0.5	0.68	0.34	0.54	0.74	0.5	0.7	0.9	0.18	0.38	0.58
ALT6	0.26	0.46	0.66	0.1	0.3	0.5	0.3	0.5	0.7	0.38	0.58	0.76	0.3	0.5	0.68	0.18	0.38	0.58	0.5	0.7	0.9	0.1	0.22	0.42
ALT7	0.7	0.9	1	0.7	0.9	1	0.38	0.58	0.76	0.42	0.62	0.78	0.38	0.54	0.7	0.54	0.74	0.92	0.54	0.74	0.92	0.5	0.7	0.88
ALT8	0.3	0.5	0.7	0.1	0.3	0.5	0.1	0.3	0.5	0	0.1	0.3	0.14	0.34	0.54	0.46	0.66	0.86	0.5	0.7	0.9	0.08	0.26	0.46
ALT9	0.34	0.54	0.74	0	0.1	0.3	0.3	0.5	0.7	0.18	0.38	0.58	0.3	0.5	0.7	0.3	0.5	0.7	0.54	0.74	0.92	0.26	0.46	0.66
ALT10	0.14	0.34	0.54	0	0.1	0.3	0.08	0.26	0.46	0.24	0.42	0.62	0.26	0.46	0.66	0.14	0.34	0.54	0.3	0.5	0.7	0.08	0.26	0.46
ALT11	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.3	0.5	0.14	0.34	0.54	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	0.7	0	0.1	0.3
ALT12	0.34	0.54	0.74	0.1	0.3	0.5	0	0.1	0.3	0.22	0.42	0.62	0.3	0.5	0.7	0.54	0.74	0.92	0.06	0.18	0.38	0	0.1	0.3
ALT13	0.18	0.38	0.58	0	0.1	0.3	0.3	0.5	0.7	0.3	0.5	0.7	0.42	0.62	0.82	0.5	0.7	0.9	0.5	0.7	0.9	0.06	0.22	0.42
ALT14	0.3	0.5	0.7	0.08	0.26	0.46	0.3	0.5	0.7	0.46	0.66	0.86	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9	0.06	0.22	0.42
ALT15	0.38	0.58	0.78	0.02	0.14	0.34	0.5	0.7	0.9	0.34	0.54	0.74	0.7	0.9	1	0.24	0.42	0.62	0.3	0.5	0.7	0	0.1	0.3
ALT16	0.38	0.58	0.76	0.5	0.7	0.9	0.38	0.58	0.78	0.38	0.58	0.78	0.34	0.54	0.74	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9
ALT17	0.26	0.46	0.66	0	0.1	0.3	0.5	0.7	0.9	0.3	0.5	0.7	0.5	0.7	0.9	0.34	0.54	0.74	0.7	0.9	1	0	0.1	0.3
ALT18	0.1	0.3	0.5	0	0.1	0.3	0	0.1	0.3	0.18	0.38	0.58	0.14	0.34	0.54	0.34	0.54	0.74	0.34	0.54	0.74	0	0.1	0.3
ALT19	0.54	0.74	0.92	0.3	0.5	0.7	0.38	0.58	0.78	0.54	0.74	0.92	0.14	0.34	0.54	0.38	0.58	0.78	0.5	0.7	0.9	0.1	0.3	0.5
ALT20	0.66	0.86	0.98	0	0.1	0.3	0.3	0.5	0.7	0.3	0.5	0.7	0.5	0.7	0.9	0.3	0.5	0.7	0.3	0.5	0.7	0.08	0.22	0.42

Tab.6. Allocating weights to the evaluation criteria of the SVCs

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8
ALT1	0.062	0.079	0.086	0.064	0.018	0.06	0.055	0.104
ALT2	0.068	0.102	0.076	0.081	0.076	0.058	0.058	0.086
ALT3	0.065	0.084	0.065	0.058	0.038	0.072	0.066	0.104
ALT4	0.071	0.106	0.069	0.078	0.079	0.055	0.058	0.099
ALT5	0.057	0.03	0.034	0.043	0.045	0.045	0.053	0.049
ALT6	0.037	0.038	0.05	0.053	0.045	0.032	0.053	0.032
ALT7	0.071	0.11	0.057	0.056	0.049	0.061	0.056	0.09
ALT8	0.041	0.038	0.03	0.012	0.031	0.055	0.053	0.035
ALT9	0.044	0.017	0.05	0.035	0.046	0.042	0.056	0.06
ALT10	0.028	0.017	0.026	0.04	0.042	0.028	0.038	0.035
ALT11	0.057	0.064	0.03	0.032	0.046	0.042	0.038	0.017
ALT12	0.044	0.038	0.013	0.039	0.046	0.061	0.016	0.017
ALT13	0.031	0.017	0.05	0.047	0.057	0.058	0.053	0.03
ALT14	0.041	0.034	0.05	0.061	0.064	0.058	0.053	0.03
ALT15	0.047	0.021	0.069	0.05	0.079	0.035	0.038	0.017
ALT16	0.047	0.089	0.057	0.054	0.049	0.058	0.053	0.091
ALT17	0.037	0.017	0.069	0.047	0.064	0.045	0.066	0.017
ALT18	0.024	0.017	0.013	0.035	0.031	0.045	0.041	0.017
ALT19	0.06	0.064	0.057	0.068	0.031	0.048	0.053	0.039
ALT20	0.068	0.017	0.05	0.047	0.064	0.042	0.038	0.031
Ej	0.986	0.928	0.971	0.982	0.982	0.992	0.99	0.935
Wj	0.061	0.304	0.124	0.076	0.078	0.036	0.044	0.277
Rank	6	1	3	5	4	8	7	2

Step 5: Normalize the fuzzy decision matrix

The fuzzy decision matrix introduced in the preceding steps (Table 5) was normalized using Eqs. 8 and 9.

Step 6: Create a weighted, normalized fuzzy decision matrix

The weights of the calculated criteria (Table 6) and the normalized fuzzy decision matrix were converted into a weighted normalized fuzzy decision matrix using Eq. 10, as displayed in Table 6.

Step 7: Calculate the distance of the alternatives from fuzzy PIS and NIS.

The distance of each alternative (A^+ and A^-, was obtained from the set of PIS and NIS using Eqs. 13 and 14.

Step 8: Determining closeness coefficients (relative degree-distance) and the tendency of alternatives to reach ideals for each criterion.

The closeness coefficient CCj was considered as

the final index for evaluating and ranking the alternatives, calculated based on Eq. 15. The results, along with the distance between the PIS and NIS, are shown in Table 8.

According to Table 8 and the evaluation criteria for the SVCs, tourism and handicrafts, textiles and clothing, and commercial logistics and transportation were ranked first, second, and third, respectively, and the SVCs, light and heavy livestock farming, and cascade farming had the lowest rank in terms of the economic development effectiveness in Yazd Province, Iran.

To strengthen the evaluation method proposed in this paper, the alternatives were prioritized using the fuzzy VIKOR method based on the decision matrix data. The ranking results are presented in Table 9. Here, the alternatives, Alt4, Alt2, and Alt7, had the highest position in both methods. A comparison of the fuzzy TOPSIS and VIKOR results indicated that the change in the positions of the alternatives was negligible (about 14%). Therefore, it was reported that the proposed method (namely, the hybrid fuzzy entropy-TOPSIS approach) in this study was appropriate for evaluating the performance of SVCs with logical accuracy.

Tab.7. Distance values, closeness coefficients, and SVC rankings

Alternatives	d^+	d^-	CC_j	Rank
ALT1	7.303	0.717	0.089	5
ALT2	7.234	0.784	0.098	2
ALT3	7.293	0.728	0.091	4
ALT4	7.2	0.816	0.102	1
ALT5	7.613	0.423	0.053	9
ALT6	7.624	0.411	0.051	11
ALT7	7.268	0.749	0.093	3
ALT8	7.676	0.367	0.046	17
ALT9	7.616	0.42	0.052	10
ALT10	7.729	0.315	0.039	19
ALT11	7.627	0.411	0.051	12
ALT12	7.717	0.327	0.041	18
ALT13	7.667	0.373	0.046	16
ALT14	7.601	0.436	0.054	8
ALT15	7.645	0.394	0.049	13
ALT16	7.34	0.684	0.085	6
ALT17	7.664	0.376	0.047	15
ALT18	7.789	0.258	0.032	20
ALT19	7.514	0.519	0.065	7
ALT20	7.647	0.39	0.049	14

Tab.8. Weighted normalized fuzzy decision matrix

Alternatives	Criteria																							
	C1			C2			C3			C4			C5			C6			C7			C8		
ALT1	0.04	0.05	0.06	0.13	0.19	0.25	0.09	0.11	0.12	0.04	0.05	0.07	0.00	0.01	0.03	0.02	0.03	0.03	0.02	0.03	0.04	0.18	0.24	0.28
ALT2	0.04	0.05	0.06	0.19	0.25	0.29	0.07	0.10	0.12	0.05	0.07	0.08	0.05	0.07	0.08	0.02	0.03	0.03	0.03	0.03	0.04	0.13	0.19	0.25
ALT3	0.04	0.05	0.06	0.14	0.20	0.26	0.06	0.08	0.10	0.03	0.05	0.06	0.02	0.03	0.05	0.03	0.03	0.04	0.03	0.04	0.04	0.18	0.24	0.28
ALT4	0.04	0.05	0.06	0.20	0.26	0.30	0.06	0.09	0.11	0.05	0.07	0.07	0.05	0.07	0.08	0.02	0.02	0.03	0.03	0.03	0.04	0.17	0.22	0.27
ALT5	0.03	0.04	0.05	0.02	0.07	0.13	0.02	0.04	0.07	0.02	0.04	0.05	0.02	0.04	0.05	0.01	0.02	0.03	0.02	0.03	0.04	0.05	0.11	0.17
ALT6	0.02	0.03	0.04	0.03	0.09	0.15	0.04	0.06	0.09	0.03	0.04	0.06	0.02	0.04	0.05	0.01	0.01	0.02	0.02	0.03	0.04	0.03	0.06	0.12
ALT7	0.04	0.05	0.06	0.21	0.27	0.30	0.05	0.07	0.09	0.03	0.05	0.06	0.03	0.04	0.05	0.02	0.03	0.03	0.02	0.03	0.04	0.14	0.20	0.25
ALT8	0.02	0.03	0.04	0.03	0.09	0.15	0.01	0.04	0.06	0.00	0.01	0.02	0.01	0.03	0.04	0.02	0.02	0.03	0.02	0.03	0.04	0.02	0.07	0.13
ALT9	0.02	0.03	0.05	0.00	0.03	0.09	0.04	0.06	0.09	0.01	0.03	0.04	0.02	0.04	0.05	0.01	0.02	0.03	0.02	0.03	0.04	0.07	0.13	0.19
ALT10	0.01	0.02	0.03	0.00	0.03	0.09	0.01	0.03	0.06	0.02	0.03	0.05	0.02	0.04	0.05	0.01	0.01	0.02	0.01	0.02	0.03	0.02	0.07	0.13
ALT11	0.03	0.04	0.05	0.09	0.15	0.21	0.01	0.04	0.06	0.01	0.03	0.04	0.02	0.04	0.05	0.01	0.02	0.03	0.01	0.02	0.03	0.00	0.03	0.09
ALT12	0.02	0.03	0.05	0.03	0.09	0.15	0.00	0.01	0.04	0.02	0.03	0.05	0.02	0.04	0.05	0.02	0.03	0.03	0.00	0.01	0.02	0.00	0.03	0.09
ALT13	0.01	0.02	0.04	0.00	0.03	0.09	0.04	0.06	0.09	0.02	0.04	0.05	0.03	0.05	0.06	0.02	0.03	0.03	0.02	0.03	0.04	0.02	0.06	0.12
ALT14	0.02	0.03	0.04	0.02	0.08	0.14	0.04	0.06	0.09	0.04	0.05	0.07	0.04	0.05	0.07	0.02	0.03	0.03	0.02	0.03	0.04	0.02	0.06	0.12
ALT15	0.02	0.04	0.05	0.01	0.04	0.10	0.06	0.09	0.11	0.03	0.04	0.06	0.05	0.07	0.08	0.01	0.02	0.02	0.01	0.02	0.03	0.00	0.03	0.09
ALT16	0.02	0.04	0.05	0.15	0.21	0.27	0.05	0.07	0.10	0.03	0.04	0.06	0.03	0.04	0.06	0.02	0.03	0.03	0.02	0.03	0.04	0.14	0.20	0.26
ALT17	0.02	0.03	0.04	0.00	0.03	0.09	0.06	0.08	0.10	0.02	0.04	0.05	0.04	0.05	0.07	0.01	0.02	0.03	0.03	0.04	0.04	0.00	0.03	0.09
ALT18	0.01	0.02	0.03	0.00	0.03	0.09	0.00	0.01	0.04	0.01	0.03	0.04	0.01	0.03	0.04	0.01	0.02	0.03	0.01	0.02	0.03	0.00	0.03	0.09
ALT19	0.03	0.05	0.06	0.09	0.15	0.21	0.05	0.07	0.10	0.04	0.06	0.07	0.01	0.03	0.04	0.01	0.02	0.03	0.02	0.03	0.04	0.03	0.09	0.14
ALT20	0.04	0.05	0.06	0.00	0.03	0.09	0.04	0.06	0.09	0.02	0.04	0.05	0.04	0.05	0.07	0.01	0.02	0.03	0.01	0.02	0.03	0.02	0.06	0.12

Tab.9. Comparison of the proposed method with the Fuzzy VIKOR method

Alternatives	Ranking Proposed	FVIKOR	Alternatives	Ranking Proposed	FVIKOR
ALT1	5	5	ALT11	12	11
ALT2	2	2	ALT12	18	18
ALT3	4	4	ALT13	16	15
ALT4	1	1	ALT14	8	8
ALT5	9	9	ALT15	13	13
ALT6	11	12	ALT16	6	6
ALT7	3	3	ALT17	15	16
ALT8	17	17	ALT18	20	20
ALT9	10	10	ALT19	7	7
ALT10	19	19	ALT20	14	14

4.1. Sensitivity analysis

To check the stability and robustness of the evaluation of the SVCs in this study, sensitivity analysis was further performed using the most common method of analyzing the sensitivity of changes in the weight of the SVC evaluation criteria (C_i) [59]. For this purpose, the weights of the criteria with the highest value were selected to allow partial changes. Then, the weights of the evaluation criteria were enlarged and reduced in three phases (viz., ±5%, ±10%, and ±15%), so this relative change in the weight of each criterion was proportional to that of the remaining ones, and adjusted in such a way that kept the total weight equal to 1 [60]. Tables 10 and 11 show the evaluation of the alternatives based on the change in the weights of criteria C_2 and C_8. As presented in Tables 10 and 11, the similarity of the evaluation with the change in the weight of the criteria was very high (about 85%), and the change in the position of the alternatives was partial. Therefore, it was concluded that the evaluation of the performance of the presented SVCs was not sensitive to the weight of the criteria, C_2 and C_8.

The results of determining the weight of the evaluation criteria stated in Step 4 of Section 4 indicate that the two criteria "High job creation" and "Positive effect on GDP" have the highest weight, which means that they have the greatest impact in determining the ranking of the options, so the selection of SVCs from these two criteria is most affected.

Tab.10. Weight sensitivity of C2 in terms of ranking

Alternatives	Weight level -15%	-10%	-5%	Original	+5%	+10%	+15%
	Ranking (Closeness coefficient)						
ALT1	5 (0.089)	5 (0.0892)	5 (0.0893)	5 (0.0894)	5 (0.0895)	5 (0.0897)	5 (0.0898)
ALT2	2 (0.0979)	2 (0.0978)	2 (0.0978)	2 (0.0977)	2 (0.0977)	2 (0.0977)	2 (0.0976)
ALT3	4 (0.0904)	4 (0.0905)	4 (0.0906)	4 (0.0907)	4 (0.0908)	4 (0.091)	4 (0.0911)
ALT4	1 (0.102)	1 (0.1019)	1 (0.1018)	1 (0.1017)	1 (0.1017)	1 (0.1016)	1 (0.1015)
ALT5	10 (0.0511)	9 (0.0516)	9 (0.0522)	9 (0.0527)	9 (0.0532)	9 (0.0537)	10 (0.0542)
ALT6	11 (0.0503)	12 (0.0506)	12 (0.0509)	11 (0.0512)	11 (0.0515)	11 (0.0518)	11 (0.0522)
ALT7	3 (0.0944)	3 (0.0941)	3 (0.0938)	3 (0.0934)	3 (0.0931)	3 (0.0928)	3 (0.0924)
ALT8	15 (0.045)	16 (0.0452)	17 (0.0454)	17 (0.0456)	17 (0.0458)	17 (0.046)	17 (0.0462)
ALT9	12 (0.0502)	11 (0.0509)	10 (0.0516)	10 (0.0523)	10 (0.053)	10 (0.0537)	9 (0.0543)
ALT10	19 (0.0379)	19 (0.0383)	19 (0.0387)	19 (0.0392)	19 (0.0396)	19 (0.04)	19 (0.0404)
ALT11	9 (0.0515)	10 (0.0513)	11 (0.0512)	12 (0.0511)	12 (0.0509)	12 (0.0508)	14 (0.0507)
ALT12	18 (0.0402)	18 (0.0403)	18 (0.0405)	18 (0.0406)	18 (0.0408)	18 (0.0409)	18 (0.041)
ALT13	17 (0.0443)	17 (0.045)	16 (0.0457)	16 (0.0464)	16 (0.0471)	16 (0.0478)	16 (0.0485)
ALT14	8 (0.0526)	8 (0.0531)	8 (0.0537)	8 (0.0542)	8 (0.0548)	8 (0.0553)	8 (0.0559)
ALT15	13 (0.047)	13 (0.0477)	13 (0.0483)	13 (0.049)	13 (0.0496)	13 (0.0503)	12 (0.051)
ALT16	6 (0.0857)	6 (0.0855)	6 (0.0854)	6 (0.0853)	6 (0.0851)	6 (0.085)	6 (0.0849)
ALT17	16 (0.0445)	15 (0.0453)	15 (0.046)	15 (0.0468)	15 (0.0475)	15 (0.0482)	15 (0.049)
ALT18	20 (0.0309)	20 (0.0313)	20 (0.0316)	20 (0.032)	20 (0.0324)	20 (0.0327)	20 (0.0331)
ALT19	7 (0.0642)	7 (0.0643)	7 (0.0644)	7 (0.0646)	7 (0.0647)	7 (0.0648)	7 (0.0649)
ALT20	14 (0.0464)	14 (0.0471)	14 (0.0478)	14 (0.0486)	14 (0.0493)	14 (0.05)	13 (0.0507)

Tab.11. Weight sensitivity of C8 on ranking

Alternatives	Weight level		-5%	Original	+5%	+10%	+15%
	-15%	-10%					
	Ranking (Closeness coefficient)						
ALT1	5 (0.0903)	5 (0.09)	5 (0.0897)	5 (0.0894)	5 (0.0891)	5 (0.0888)	5 (0.0885)
ALT2	2 (0.0972)	2 (0.0974)	2 (0.0976)	2 (0.0977)	2 (0.0979)	2 (0.0981)	2 (0.0983)
ALT3	4 (0.0914)	4 (0.0912)	4 (0.091)	4 (0.0907)	4 (0.0905)	4 (0.0903)	4 (0.09)
ALT4	1 (0.1018)	1 (0.1018)	1 (0.1018)	1 (0.1017)	1 (0.1017)	1 (0.1017)	1 (0.1017)
ALT5	9 (0.0523)	9 (0.0524)	9 (0.0525)	9 (0.0527)	9 (0.0528)	9 (0.053)	9 (0.0532)
ALT6	11 (0.0501)	11 (0.0504)	11 (0.0508)	11 (0.0512)	12 (0.0516)	12 (0.052)	11 (0.0524)
ALT7	3 (0.0935)	3 (0.0935)	3 (0.0935)	3 (0.0934)	3 (0.0934)	3 (0.0934)	3 (0.0933)
ALT8	17 (0.0448)	17 (0.0451)	17 (0.0453)	17 (0.0456)	17 (0.0458)	17 (0.046)	17 (0.0463)
ALT9	10 (0.0522)	10 (0.0523)	10 (0.0523)	10 (0.0523)	10 (0.0523)	10 (0.0522)	12 (0.0522)
ALT10	19 (0.0388)	19 (0.0389)	19 (0.039)	19 (0.0392)	19 (0.0393)	19 (0.0394)	19 (0.0395)
ALT11	12 (0.0494)	12 (0.05)	12 (0.0505)	12 (0.0511)	11 (0.0516)	11 (0.0522)	10 (0.0527)
ALT12	18 (0.0393)	18 (0.0398)	18 (0.0402)	18 (0.0406)	18 (0.041)	18 (0.0415)	18 (0.0419)
ALT13	15 (0.0451)	15 (0.0455)	16 (0.046)	16 (0.0464)	16 (0.0468)	16 (0.0472)	16 (0.0477)
ALT14	8 (0.0526)	8 (0.0532)	8 (0.0537)	8 (0.0542)	8 (0.0548)	8 (0.0553)	8 (0.0559)
ALT15	13 (0.0472)	13 (0.0477)	13 (0.0483)	13 (0.049)	13 (0.0496)	13 (0.0503)	13 (0.0509)
ALT16	6 (0.0858)	6 (0.0856)	6 (0.0854)	6 (0.0853)	6 (0.0851)	6 (0.0849)	6 (0.0847)
ALT17	16 (0.0449)	16 (0.0454)	15 (0.0461)	15 (0.0468)	15 (0.0474)	15 (0.0481)	15 (0.0488)
ALT18	20 (0.031)	20 (0.0314)	20 (0.0317)	20 (0.032)	20 (0.0323)	20 (0.0326)	20 (0.033)
ALT19	7 (0.0632)	7 (0.0636)	7 (0.0641)	7 (0.0646)	7 (0.065)	7 (0.0655)	7 (0.0659)
ALT20	14 (0.047)	14 (0.0477)	14 (0.0481)	14 (0.0486)	14 (0.049)	14 (0.0495)	14 (0.0499)

The findings of the sensitivity analysis conducted according to the data in Tables 10 and 11 show that changing the weight of these two criteria does not cause a fundamental change in the ranking results. Therefore, it can be stated that the ranking performed has the necessary strength and the ranking of the SVCs is not sensitive to changing the weight of the criteria.

5. Discussion

The findings were compared with those of other studies and then discussed in terms of the evaluation criteria for VCs. Schneemann (2015) [8] mentioned a series of economic and environmental criteria as evaluation criteria for VCs, which were included among those presented in this study. As stated in Narula and Bhattacharyya (2017) [9] and Mertens et al. (2019) [10], VCD improved household income, and the two criteria of "high economic value" and "a positive effect on GDP" were also considered to evaluate SVCs in the present study. According to Havardi-Burger et al. (2021) [11], environmental and socioeconomic aspects were investigated in the evaluation of the desired VCs, which were among the evaluation criteria in this study. The export- and market-oriented criterion of VCs was also confirmed by Wubet et al. (2022) [12] and Mehrez et al. (2023) [17]. Nahar et al. (2022) [14] highlighted the economic value of VCs and found that "high economic value" in SVCs could be among the evaluation criteria. In this study, a criterion for evaluating VCs was the "possibility of productivity", as substantiated by Songsermsawas et al. (2023) [15]. The criteria of "high economic value" and "no reliance on natural resources" were similarly used in this study to evaluate SVCs, which were cited in the framework proposed by Moretti et al. (2023) [16]. Some limitations of this study include the following: the first limitation is related to the location of the study and the regional limitations. One of the existing issues in the Yazd province is the lack of balanced regional development. In some areas, large investors have been made and there is a great desire for new investment, while that area does not have the capacity to accept new development. In some areas, there are restricted areas and the least development and investment has been made, and there is less desire to invest in those areas. The lack of desire to invest will lead to the lack of development of some SVCs. Another limitation is the development of some industries with multiple units in recent years, which are not appropriate for the climate of Yazd province, and their development causes environmental degradation and a large consumption of natural resources. Considering the volume of

investment in these industries in Yazd province and the localization of these industries, their redevelopment in the form of SVC development is challenging for policymakers. Another limitation of this study is that, given the novelty and specialization of the topic of SVCs, data on some industrial sectors and services that are included in VCs are not integrated and analyzable in the responsible executive bodies.

6. Managerial and Practical Implications

A concern of public sector managers and governments in countries is supporting the private sector for the development of the country. It is essential for policymakers and government managers that the country's resources are spent in a category that achieves the highest added value while respecting the limitations. This sensitivity is much more prominent in local and regional sectors that have climatic, cultural, and social advantages and special characteristics. Therefore, government sector managers from the perspective of support and facilitation and private sector managers from the perspective of investment are always looking for categories that, by taking advantage of the existing advantages, achieve the highest added value in starting a new business or strengthening existing businesses. Hence, the definition of the SVC development project is in this regard. The development of SVCs plays a very important role in the economic development of countries. The most important goal of the SVC development project is to strengthen local VCs and promote them to the national level and ultimately to the global level. Identifying and evaluating SVCs in each region is an important and challenging issue. Managers and planners need a multidimensional evaluation model to select SVCs, which is considered a multi-criteria decision-making problem due to the involvement of some criteria.

The approach presented in this study helps decision-makers select the best SVCs. The presented method encourages researchers and managers to analyze the evaluated local VCs using various techniques, identify missing and inefficient links, and suggest solutions to improve the effectiveness of the VC. In this study, 20 active SVCs in the Yazd Province, Iran, were identified by considering the maximum number of existing backward and forward linkages. To evaluate the VCs, eight evaluation criteria were further used with a developmental method, and the SVCs were ranked using the hybrid fuzzy entropy-TOPSIS approach.

7. Conclusion

In developing countries, due to their rapid progress and accompanying economic and social development, the issue of VCs is of great interest. Given the importance of VCs and their role in development, governments in each country are always looking to identify and plan to improve the VCs formed in a region. Investors are also looking to invest in sectors that will bring them the most added value. Therefore, identifying effective VCs based on the environmental conditions in each region is very important. From an international perspective, identifying and evaluating local VCs and planning to improve them to a global level can be considered one of the development strategies for each country. Evaluating VCs has multiple dimensions due to their role in economic and social development. Therefore, selecting strategic VCs is among the multiple decision-making issues. In this study, a scientific framework has been presented to evaluate and rank SVCs in the Yazd province. First, the value-creating sectors of the Yazd province were identified by studying upstream documents and seeking opinions from experts. After matching them with the concept of VCs, 20 VCs formed in the Yazd province were identified. By studying the literature on the subject and seeking opinions from experts, 8 evaluation criteria were determined. The Shannon entropy method was used to weight the evaluation criteria, and the fuzzy TOPSIS method was used to rank the VCs. The results indicate that among the evaluation criteria, the two criteria of "High job creation" and "Positive effect on GDP" have the highest weight among the criteria, and the 5 SVCs of Yazd province are tourism and handicrafts, textiles and clothing, commercial logistics and transportation, non-metallic minerals, and mining and metals industries, respectively.

The results of the sensitivity analysis of the evaluation criteria for the VCs ultimately demonstrated that the ranks obtained by the hybrid fuzzy entropy-TOPSIS method were not affected by the change in the weight of the criteria.

It was thus suggested that future research should analyze the SVCs identified in this study, which had the highest impact on regional development.

It was also better to detect missing or inefficient linkages and improve each chain based on local conditions. It was also recommended to identify financing models for SVCs based on the methods presented in this study and to propose the best model for each linkage.

References

[1]. Walters, D., & Lancaster, G., 2000. Implement a value strategy through the value chain. Management Decision, 38(3), pp. 160-178.

[2]. Khorasani, T., & Milad, S. M., 2012. Integrated and comprehensive study of design driven innovation added value.

[3]. Song, H., Liu, J. and Chen, G., 2013. Tourism value chain governance: Review and prospects. Journal of travel research, 52(1), pp. 15-28.

[4]. Ensign, P. C. 2001. Value chain analysis and competitive advantage. Journal of General Management, 27(1), pp. 18-42.

[5]. Porter, V. C. M., 1985. What Is Value Chain. E-Commer, pp. 1-13.

[6]. Shank, J.K. and Govindarajan, V., 1993. Strategic cost management: A new tool for competitive advantage. Simon and Schuster.

[7]. Levicki, C., 2003. Interactive strategy workout: Analyze and develop business fitness. Pearson Education.

[8]. Schneemann, J., 2015. Guidelines for Value Chain Selection: Integrating economic, environmental, social and institutional criteria.

[9]. Narula, S.A., Bhattacharyya, S., 2017. Off-grid electricity interventions for cleaner livelihoods: A case study of value chain development in the Dhenkanal district of Odisha. Journal of Cleaner Production, 142, pp. 191-202.

[10]. Mertens, A.; Van Lancker, J.; Buysse, J.; Lauwers, L.; Van Meensel, J., 2019. Overcoming nontechnical challenges in bioeconomy value-chain development: Learning from practice. Journal of cleaner production, 231, pp. 10-20.

[11]. Havardi-Burger, N., Mempel, H. and Bitsch, V., 2021. Framework for sustainability assessment of the value chain of flowering potted plants for the German market. The Journal of Cleaner Production, 329, pp. 129684.

[12]. Wubet, G.K., Zemedu, L. and Tegegne, B., 2022. Value chain analysis of potato in the Farta district of the South Gondar zone, Ethiopia's national regional state. Heliyon, 8(3).

[13]. Deka, N.; Goswami, K., 2022. Organic cultivation and sustainable value chain development for tea smallholders: Findings from Assam, India. Sustainable Production and Consumption, 32, pp. 562-579.

[14]. Nahar, A.; Mila, F.A.; Culas, R.J.; Amin, M.R., 2022. Assessing the factors and constraints for the value chain development of dairy food products in Bangladesh. Heliyon, 8(10).

[15]. Songsermsawas, T., Kafle, K. and Winters, P., 2023. Decomposing the impacts of an agricultural value chain development project by ethnicity and gender in Nepal. World Development, 168, pp. 106259.

[16]. Moretti, M., Belliggiano, A., Grando, S., Felici, F., Scotti, I., Ievoli, C., Blackstock, K., Delgado-Serrano, M.M. and Brunori, G., 2023. Characterizing value chain contributions to resilient and sustainable development in European mountain areas. Journal of Rural Studies, 100, pp. 103022.

[17]. Mehrez, K.H., Khemira, H., Meddabesh, A.M., 2023. Marketing strategies for value chain development: Case of Khawlani coffee-Jazan Region, Saudi Arabia. Journal of the Saudi Society of Agricultural Sciences.

[18]. Surange, V.G., Bokade, S.U., 2023. Modeling Interactions Among Critical Risk Factors in Indian Manufacturing Industries Using ISM and DEMATEL. Journal of The Institution of Engineers (India): Series C, 104(1), pp. 123-147. https://doi.org/10.1007/s40032-022-00896-8.

[19]. Cao, J. and Xu, F., 2022. The entropy-based fuzzy TOPSIS method for investment decision optimization of large-scale projects. Computational Intelligence and Neuroscience, 2022. https://doi.org/10.1155/2022/4381293.

[20]. Surange, V.G.; Bokade, S.U.; Singh, A.K.; Teli, S.N., 2022. Prioritizing roadblocks adopt industry 4.0 technologies in manufacturing industries using VIKOR. Materials Today: Proceedings, 50, pp. 2194-2200. https://doi.org/10.1016/j.matpr.2021.09.448.

[21]. Wang, T.C.; Thu Nguyen, T.T.; Phan, B.N., 2022. Higher education performance analysis using the entropy-TOPSIS method: A case study in Viet Nam private universities. Measurement and Control, 55(5-6), pp. 385-410. https://doi.org/10.1177/00202940221089504.

[22]. Simon, H.A., 1960. The new science of management decision.

[23]. Alao, M.A.; Ayodele, T.R.; Ogunjuyigbe, A.S.O.; Popoola, O.M., 2020. Multi-criteria decision-based waste-to-energy technology selection using entropy-weighted TOPSIS technique: The case study of Lagos, Nigeria. Energy, 201, 117675, doi: 10.1016/j.energy.2020.117675.

[24]. Saaty, T. L., 1988. What is the analytic hierarchy process? (pp. 109-121). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-83555-1_5.

[25]. Junior, F.R.L.; Osiro, L.; Carpinetti, L.C.R., 2014. A comparison of the Fuzzy AHP and Fuzzy TOPSIS methods to supplier selection. Applied soft computing, 21, pp. 194-209. https://doi.org/10.1016/j.asoc.2014.03.014.

[26]. Behzadian, M.; Kazemzadeh, R.B.; Albadvi, A.; Aghdasi, M., 2010. PROMETHEE: A comprehensive literature review of methodologies and applications. European Journal of Operational Research, 200(1), pp. 198-215. https://doi.org/10.1016/j.ejor.2009.01.021.

[27]. Vetschera, R. and De Almeida, A.T., 2012. A PROMETHEE-based approach to portfolio selection problems. Computers and Operations Research, 39(5), pp. 1010-1020. https://doi.org/10.1016/j.cor.2011.06.019.

[28]. Roy, B., 1968. Classification et choix en présence de points de vue multiples. Revue française d'informatique et de recherche opérationnelle, 2(8), pp. 57-75. https://doi.org/10.1051/ro/196802v100571.

[29]. Hwang, C.L., Lin, M.J., 2012. Group decision-making under multiple criteria: methods and applications (Vol. 281). Springer Science & Business Media.

[30]. Taylan, O.; Bafail, A.O.; Abdulaal, R.M.; Kabli, M.R., 2014. Construction project selection and risk assessment using fuzzy AHP and fuzzy TOPSIS methodologies. Applied Soft Computing, 17, pp. 105-116. https://doi.org/10.1016/j.asoc.2014.01.003.

[31]. Yurdakul, M.; Ic, Y.T., 2005. Development of a performance measurement model for manufacturing companies using the AHP and TOPSIS approaches. International Journal of Production Research, 43(21), pp. 4609-4641. https://doi.org/10.1080/00207540500161746.

[32]. Banadkouki, M.Z., Lotfi, M.M., 2021. Selection of computer-integrated manufacturing technologies using a combined fuzzy analytic hierarchy process and fuzzy TOPSIS. International Journal of Industrial Engineering & Production Research, 32(1), pp. 105-120. 10.22068/ijiepr.32.1.105.

[33]. Chen, T. Y. (2012). Comparative analysis of SAW and TOPSIS based on interval-valued fuzzy sets: Discussion of score functions and weight constraints. Expert Systems with Applications, 39(2), pp. 1848-1861. https://doi.org/10.1016/j.eswa.2011.08.065.

[34]. Memariani, A.; Amini, A.; Alinezhad, A., 2009. Sensitivity analysis of the simple additive weighting method (SAW): the results of changing the weight of one attribute on the final ranking of alternatives. Journal of Optimization in Industrial Engineering, 2(4), pp. 13-18.

[35]. Thor J, Ding SH, Kamaruddin S. Comparison of multi-criteria decision-making methods from the maintenance alternative selection perspective. The International Journal of Engineering and Science 2013; 2(6): 27-34.

[36]. Wood, D. A., 2016. Supplier selection for developing petroleum industry facilities by applying multi-criteria decision-making techniques, including fuzzy and intuitionistic fuzzy TOPSIS with flexible entropy weighting. Journal of Natural Gas Science and Engineering, 28, pp. 594-612. https://doi.org/10.1016/j.jngse.2015.12.021.

[37]. Elsayed, E.A., Dawood, A.S. and Karthikeyan, R.J.I.J.E.T.T., 2017. Evaluating alternatives through the application of the TOPSIS method with entropy weight. Int. J. Eng. Trends Technol. 46(2), pp. 60-66. https://doi.org/10.14445/22315381/ijett-v46p211.

[38]. Rao, R.V., Patel, B.K., 2010. A subjective and objective integrated multiple attribute decision-making method for material selection. Materials & Design, 31(10), pp. 4738-4747. https://doi.org/10.1016/j.matdes.2010.05.014.

[39]. Dammak, F.; Baccour, L.; Alimi, A.M., 2015, August. Impact of criterion weights techniques in the TOPSIS method of multi-criteria decision making in crisp and intuitionistic fuzzy domains. In 2015 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE) (pp. 1-8). IEEE. https://doi.org/10.1109/fuzz-ieee.2015.7338116.

[40]. Aydoğdu, E.; Güner, E.; Aldemir, B.; Aygün, H., 2023. Complex spherical fuzzy TOPSIS based on entropy. Expert Systems with Applications, 215, p. 119331. https://doi.org/10.1016/j.eswa.2022.119331.

[41]. Zhao, C. Y., 2009. This study evaluates the performance of enterprises' knowledge value chain management based on entropy weight TOPSIS. In the 2009 International Conference on Management Science.

[42]. Aghajani, H.; Ahmadpour, M., 2011. Application of fuzzy topsis to rank supply chain suppliers in automobile manufacturing companies in Iran. Fuzzy Information and Engineering, 3, pp. 433-444.

[43]. Zeng, Y., 2011. Determination Model for TOPSIS-Based Global Value Chain Governance Structure. In 2011 International Conference on Management and Service Science (pp. 1-4). IEEE.

[44]. Mousaei, A., & Hatefi, M. A., 2015. A Decision Support System (DSS) to select the premier fuel to develop in the value chain of natural gas. Iranian Journal of Oil and Gas Science and Technology, 4(3), pp. 60-76.

[45]. Liu, Y.; Eckert, C.; Yannou-Le Bris, G.; Petit, G., 2019. A fuzzy decision tool to evaluate suppliers' sustainable performance in an agrifood value chain. Computers and Industrial Engineering, 127, pp. 196-212.

[46]. An, Y.; Tan, X.; Gu, B.; Zhu, K.; Shi, L.; Ding, Z., 2023. Assessment of renewable energy development in Belt and Road Initiative countries: An entropy- and TOPSIS approach. Energy Reports, 9, pp. 166-181. https://doi.org/10.1016/j.egyr.2023.01.129.

[47]. Zadeh, L.A., 1965. Fuzzy sets. Information and control, 8(3), pp. 338-353.

[48]. Qelich, W., Khansari, R., 2020. Analysis of the Capacity of Profit-making Contracts in Islamic Microfinance Systems using Fuzzy TOPSIS Method. Journal of Iranian Economic Issues, 7(1), pp. 211-244.

[49]. Zhang, S.F. and Liu, S.Y., 2011. A GRA-based intuitive fuzzy multicriteria group decision-making method for personnel selection. Expert Systems with Applications, 38(9), pp. 11401-11405.

[50]. Ertuğrul, İ., & Karakaşoğlu, N., 2008. Comparison of fuzzy AHP and fuzzy TOPSIS methods for facility location selection. The International Journal of Advanced Manufacturing Technology, 39(7), 783-795. https://doi.org/10.1007/s00170-007-1249-8.

[51]. Deng, H., 1999. Multicriteria analysis with fuzzy pairwise comparison. International Journal of Approximation, 21(3), pp. 215-231. https://doi.org/10.1016/s0888-613x(99)00025-0.

[52]. Shannon, C.E., 2001. A mathematical theory of communication. ACM SIGMOBILE mobile computing and communications review, 5(1), pp. 3-55.

[53]. Dos Santos, B.M.; Godoy, L.P.; Campos, L.M., 2019. Performance evaluation of green suppliers using entropy-TOPSIS-F. Journal of Cleaner Production, 207, pp. 498-509.

[54]. Mavi, R.K.; Goh, M.; Mavi, N.K., 2016. Supplier selection using Shannon entropy and fuzzy TOPSIS in the context of supply chain risk management. Procedia-Social and Behavioral Sciences, 235, pp. 216-225. https://doi.org/10.1016/j.sbspro.2016.11.017.

[55]. P. Sen and J. B. Yang, 2012. Multiple criteria decision support in engineering design. Springer Science & Business Media.

[56]. Wang, Y.M. and Elhag, T. M., 2006. The fuzzy TOPSIS method is based on alpha level sets and can bridge risk assessment. Expert Systems with applications, 31(2), pp. 309-319. https://doi.org/10.1016/j.eswa.2005.09.040.

[57]. Banadkouki, M. R. Z., 2023. Selection of strategies to improve energy efficiency in industry: A hybrid approach using entropy weight method and fuzzy TOPSIS. Energy, p. 128070.

[58]. Hsieh, T. Y., Lu, S.T. and Tzeng, G. H., 2004. Fuzzy MCDM approach for the selection of planning and design tenders in public office buildings. International Journal of Project Management, 22(7), pp. 573-584. https://doi.org/10.1016/j.ijproman.2004.01.002.

[59]. Li, P.; Qian, H.; Wu, J.; Chen, J., 2013. Sensitivity analysis of the TOPSIS method for water quality assessment: I. Sensitivity to the parameter weights. Environmental monitoring and assessment, 185, pp. 2453-2461. https://doi.org/10.1007/s10661-012-2723-9.

[60]. Chauhan, R.; Singh, T.; Tiwari, A.; Patnaik, A.; Thakur, N.S., 2017. Hybrid entropy–TOPSIS approach for energy performance prioritization in a rectangular channel employing impinging air jets. Energy, 134, pp. 360-368. https://doi.org/10.1016/j.energy.2017.06.021.

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