Environmental Strategic Orientations for Improving Green Innovation Performance in Fuzzy Environment - Using New Fuzzy Hybrid MCDM Model

Ming-Tsang Lu, Gwo-Hshiung Tzeng, and Ling-Lang Tang

Abstract

The effects of environmental strategic orientation toward green innovation for promoting the firm's performance and increasing the business competitive advantage are continuing to garner much attention. As the electronics industry attempts to integrate environmental practices and move in the direction of environmental sustainability, managers should consider to extending their efforts for enhancing environmental practices, green product and process designs by using their strategic orientations on green innovation in network relationship problems. However, few studies have discussed this issue or proposed strategic orientations to help improve green innovation performance in fuzzy environment. The purpose of this study is to address this problem, using the novel method of new fuzzy hybrid MCDM (multiple criteria decision-making), including new fuzzy DEMATEL (fuzzy decision-making trial and evaluation laboratory), fuzzy DANP (fuzzy DEMATEL-based ANP) and VIKOR, to examine the interdependent and feedback problems among various dimensions/criteria of environmental strategic orientations. An empirical case of electronics industry as example is illustrated to show the proposed new methods and ultimately to present the best improvement strategies for decision-makers to achieve aspiration level.

Keywords: Strategic orientations, green innovation, fuzzy DEMATEL, fuzzy DANP, VIKOR.

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1. Introduction

Issues of environmental management have become more important in fuzzy environment, as they face more intense inspection from dissimilar stakeholder groups, including end consumers, industrial customers, suppliers, and electronics institutions [1]. In recent years, environmental management has attracted interest from the electronics industry, international organizations and governments around the globe and has evolved to include boundary-spanning activities, such as green supply chain management, green procurement, green specifications, green innovation, environmental quality, environmental management intentions, and so on. [2-8]. With increasing government regulation and stronger public realization of the needs for environmental protection, for example, the electronics industries simply cannot ignore environmental issues today if they want to survive in the global market. Furthermore, to adhere to environmental regulations for selling products in certain countries, industries must be to implement some strategies for voluntarily reducing the environmental impacts of their services or products. The integration of economic, environmental and social performances to achieve sustainable development is a major business challenge for the new century [9]. Hence, the effects of environmental strategic orientation on green innovation are for promoting the firm's performance and increasing the business competitive advantage. As the industry such as electronics industry attempts to contemplate the integration of environmental practices and move in the direction of environmental sustainability, management should extend their efforts to enhance environmental practices in green products and process designs towards their strategic orientation to green innovation in network relationship problems.

The purpose of the present study is to address for solving these problems using new fuzzy hybrid MCDM model to examine the interdependent and feedback problems among various dimensions/criteria of green innovation performance and, ultimately, to suggest the best improvement strategies for decision-makers to achieve aspiration level. When experts fill out questionnaires, their judgments and preferences are hard to quantify in exact numerical values due to the inherent vagueness of human language by perception feeling. Therefore, we apply fuzzy set theory to handle human language by designing a survey questionnaire with triangular fuzzy numbers scales. So a fuzzy DEMATEL technique is used to construct an influential network relations-map (INRM), which then is used to illustrate the influential network of the determinants related to green innovation performance. Subsequently the fuzzy DEMATEL-based ANP (fuzzy DANP) is employed to determine the exact influential weights of the criteria for further analysis, VIKOR, to address to how to reduce the previous gaps distances for achieving the aspiration level in each dimension/criterion.

The remainder of this study is structured as follows. Section 2 reviews the prior literature to form the dimensions and criteria of environmental strategic orientation model for green innovation performance and set out our conceptual model. Section 3 describes the new fuzzy hybrid MCDM model. Section 4 provides an empirical example with applications and discusses the result's analysis. Section 5 presents our conclusions.

2. Literature Review

This study focuses on the environmental strategic orientations such as market orientation, entrepreneurial orientation, learning orientation, resource orientation and natural environmental orientation (NEO) as explanatory and predictive variables for green innovation performance. This research model is proposed to address this decision evaluation green innovation performance issue. All infrastructural dimensions and critical evaluation criteria hypothesized in this study and natures of their expected relationships with green innovation performance and environmental strategic orientations are discussed next.

2.1 Green innovation performance and environmental strategy orientations

Green innovation performance is one of the most significant factors for the sustainable development of firms; it refers to hardware or software innovation that is related to green products or processes, including innovation in technologies that are involved in pollution waste recycling, green product designs, energy-saving, and corporate environment management [5]. Many companies know that the more environmentally friendly they become, the more effort will add the business competitiveness not erode them, even though it increases costs and will not deliver immediate financial benefits [10]. Executives behave as if they have to choose between the largely social benefits of developing sustainable products or processes and the financial costs of doing so. However, that is simply not true. There is a great deal of research to show that sustainable organizational and technological innovations will yield both bottom-line and top-line returns. Becoming environmentally friendly lowers costs because firms end up reducing the inputs that they use [10]. Indeed, the goals of corporate innovation for firm sustainability and the quest for sustainability are already starting to transform the competitive landscape, which forces firms to change the way they think about products, technologies, processes, and business models. The key to progress, particularly in times of economic crisis, is green innovation [10]. However, strategic decision-making for green innovation performance is a critical issue. We have reviewed the literature of related to strategic orientation factors for promoting environmental strategic orientation toward green innovation, including market orientation, entrepreneurial orientation, learning orientation, resource orientation, and natural environmental orientation.

According to market-based capabilities create value for the firm within three important dimensions of innovation performance; in this study we adopt new product development (NPD) performance, supply chain management performance and customer management (CM) performance for investigating green innovation performance [11-14]. Ramaswami et al. [14] believe that the firm's strategy is likely to influence all three business processes (NPD, SCM and CM) to create performance and value. Owing to this statement, our study adopted NPD performance, SCM performance and CM performance as the factors of a firm's performance with respect to the kind of environmental strategic orientations managers have towards green innovation performance.

We observe that the previous literature generally argues that certain types of strategic orientation could achieve certain types of performance, but there are few studies that have researched which type is important for electronics industries to make optimal decisions. In this paper, we review the criteria for environmental strategic orientations (market orientation, entrepreneurial orientation, learning orientation, resource orientation and natural environmental orientation) for the evaluation of green innovation performance.

2.2 Criteria of strategic orientations for evaluation

2.2.1. Market Orientation

Market orientation, in terms of corporate culture, characterizes an organization's disposition to deliver superior value to its customers continuously [15]. The creation of superior customer value entails an organization-wide commitment to continuous information-gathering and coordination of customers' needs, competitors' capabilities, and the provisions of other significant market agents and authorities [16]. This results in an integrated effort on the part of the employees and across departments in an organization, which, in turn, gives rise to superior performance [17]. A closer look at the market orientation construct reveals two prevalent blueprints for delivering superior customer value. First, Kohli and Jaworski [17] outline a framework that deals with the information management protocol and includes generation and dissemination of and responsiveness to market intelligence, such that the benefits derived from the information can be enhanced when shared among the functions in an organization. In support of this study, this definition set forth by Narver and Slater [18] consists of three behavioral components - customer orientation, competitor orientation, and inter-functional coordination- each of which is engaged in intelligence generation, dissemination, and responsiveness to the collected information. Furthermore, they posit that the three core behavioral components are equally important in their informational value. In summary, market orientation scholars designate a market-oriented corporate culture as a significant factor in achieving superior corporate performance. Therefore, the present study adopts this conceptualization to examine the construct of market orientation criteria, including customer orientation, competitor orientation, and inter-functional coordination.

2.2.2. Entrepreneurial Orientation

Entrepreneurial orientation reflects a firm's propensity to engage in "*the pursuit of new market opportunities and the renewal of existing areas of operation*" [19]. It promotes values such as being highly proactive toward market opportunities, tolerant of risk, and receptive to innovations [20-21]. Accordingly, the ability to initiate change, take risks, and innovate distinguishes entrepreneurial firms [22]. Entrepreneurial orientation highlights the spirit of creating new business out of ongoing practices and rejuvenating stagnant companies, which is often accomplished through the introduction of breakthrough innovations [20]. As Miller notes, an entrepreneurial firm is one that "*engages in product market innovations, undertakes somewhat risky ventures and is the first to come up with 'proactive' innovations*" [23]. In particular, the emphasis on being proactive toward new opportunities cultivates capacities that enable the firm to create products not only ahead of competitors but also ahead of the recognition of existing customers [16]. Often, this proactive quality requires substantial financial and managerial commitment. With its risk-taking nature, an entrepreneurial firm is willing to devote the necessary resources to opportunities that may result in costly failures [22]. Therefore, the present study adopts this conceptualization to examine the construct of entrepreneurial orientation criteria, including proactiveness, innovativeness and risk-taking.

2.2.3. Learning orientation

Learning orientation refers to the organization-wide activity of creating and using knowledge to enhance competitive advantage [24]. This includes obtaining and sharing information about market changes, customer needs, and competitor actions as well as development of new technologies to create new products that are superior to those of competitors [25-27]. Learning orientation is conceptualized as a set of values that influence the degree to which an organization is satisfied with its theories in use, mental models, and dominant logics, which may or may not have their bases in the marketplace [28-29]. Firms with strong learning orientations encourage or even require employees to constantly question the organizational norms that guide their activities and organizational actions [30-33]. In this respect, learning orientation affects the degree to which organizational members are encouraged, even required, to think outside the box. Hence, it has a direct bearing on the degree to which higher-order learning occurs [16]. Values that are routinely associated with the organization's learning capabilities revolve around its commitment to learning, open-mindedness, and shared vision [11, 30, 32-35]. Therefore, the present study adopts this conceptualization to examine the construct of learning orientation criteria, including commitment to learning, open-mindedness and shared vision.

2.2.4. Resource Orientation

The resource orientation scale is applied in this study and assesses the extent to which a firm is oriented toward the development of valuable and unique resource bundles within the firm [36]. Resource orientation- composed of the three dimensions of synergy, uniqueness, and dynamism- describes the degree to which a firm practices a resource-based view. The ultimate objective of resource orientation is to create superior value for the firm by deploying unique and costly-to-imitate resource bundles for the purpose of exploiting environmental opportunities and neutralizing threats [36]. Resource orientation aims to clarify how a firm's resources drive its performance in a dynamic competitive environment [37]. Resource orientation is primarily internally oriented, in that its focus lies with the development and deployment of unique firm resources. Consistent with the tenets of the resource-based view, it is concerned with accumulating a unique resource base that is immobile and heterogeneous

[38]. Hence, firms devote efforts to generating a resource base that will be difficult and costly, if not impossible, to imitate. They then use this resource base to exploit any opportunities or to neutralize any threats that arise in the external environment. The resource orientation is composed of three dimensions: synergy (synergistic benefits across the organization); uniqueness (resource uniqueness to the organization); and dynamism (the enhancement of the organization's dynamic capabilities). Resource orientation describes the degree to which a firm practices a resource-based view. Dynamism captures the use of resources as triggers for the organization to learn and adapt to change [39]. Hence, the present study adopts this conceptualization to examine the construct of resource orientation criteria, including synergy, uniqueness and dynamism.

2.2.5. Natural environmental orientation

Although the literature sheds some light on the philosophy of corporate environmentalism, it is unclear as to which specific activities help to translate the philosophy into practice, engendering a corporate NEO. This study extends previous studies by proposing a higher-order construct of NEO that is composed of three core themes, or first-order factors: entrepreneurship, corporate social responsibility, and commitment to the natural environment [40, 41]. Menguc and Ozanne have identified these three core resources (e.g., entrepreneurship, CSR, and environmental commitment) as resources that will give rise to a NEO rather than define the NEO process [42]. Descriptively, the definition is a starting point for examining the components of an NEO. Normatively, it is also a starting point for prescribing an optimal definition of an NEO, one that has the greatest capacity to transform an organization into a natural environmentally oriented organization [42]. Hence, the present study adopts this conceptualization to examine the construct of natural environmental orientation criteria, including entrepreneurship, corporate social responsibility and commitment to the natural environment.

Based on the environmental strategic orientations, five dimensions and fifteen criteria have an impact on green innovation performance in fuzzy environment. The literature review shows that market orientation is affected by three criteria- customer orientation, competitor orientation, and inter-functional coordination; entrepreneurial orientation is affected by three criteria- proactiveness, innovativeness and risk taking; learning orientation is affected by three criteria- open-mindedness, shared vision, and entrepreneurship; resource orientation is affected by three criteria- synergy, uniqueness, dynamism; and natural environmental orientation is affected by three criteria- entrepreneurship, corporate social responsibility, and commitment to the natural environment. These criteria are presented in Table 1.

According to the above discussion, we developed the following corresponding to the fifteen criteria in Figure 1 as environmental strategic orientations framework for improving green innovation performance. The relationship can be examined by the new hybrid fuzzy MCDM techniques of fuzzy DEMATEL, fuzzy DANP and VIKOR to present models with gap values that are useful for predicting strategic orientations to improve the performance of green innovation within the dimensions of fuzzy environment.

Table 1. Explanation of criteria.

Dimensions/ Criteria	**Descriptions**
Market orientation (D_1)	
customer orientation (C_1)	customer orientation is the sufficient understanding of one's target buyers to be able to create superior value for them continuously
competitor orientation (C_2)	understands the short-term strengths and weaknesses and long-term capabilities and strategies of both the key current and potential competitors
inter-functional coordination (C_3)	the coordinated utilization of company resources in creating superior value for target customers.
Entrepreneurial Orientation (D_2)	
innovativeness(C_4)	the degree to which a firm engages in and embraces new ideas, novelty, experimentation and creativity that may lead to new products, services or processes
risk taking (C_5)	the degree to which managers are willing to make large and risky resource commitments
proactiveness (C_6)	the degree to which a firm acts in anticipation of future market needs and changes
Learning orientation (D_3)	
commitment to learning (C_7)	degree to which an organization values and promotes learning, is likely to foster a learning climate
shared vision (C_8)	an organization-wide focus on learning
open-mindedness (C_9)	the willingness to critically evaluate the organization's operational routine and to accept new ideas
Resource orientation (D_4)	
Synergy (C_{10})	synergistic benefits across the organization
Uniqueness (C_{11})	resource uniqueness to the organization
Dynamism (C_{12})	the enhancement of the organization's dynamic capabilities
Natural environmental orientation (D_5)	
entrepreneurship (C_{13})	the degree to which a company takes calculated risks, is innovative, and demonstrates proactiveness
corporate social responsibility (C_{14})	business should go beyond economic concerns, enumerates, the natural environment as a particular issue of relevance, and argues that a proactive stance is necessary
commitment to the natural environment (C_{15})	requires organizations to take a long-term perspective to utilize policies and strategies that support this long-term view and to allocate the necessary resources accordingly

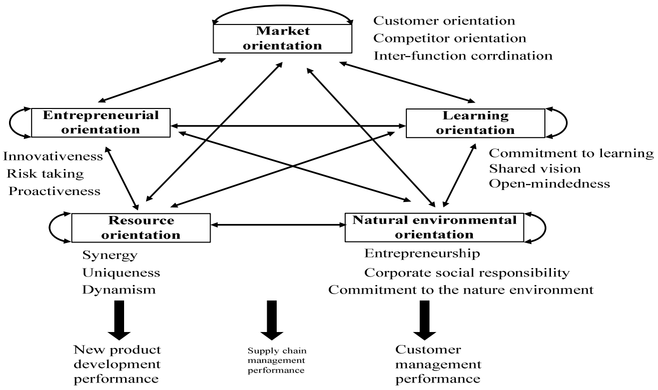

Figure 1. The impact on environmental strategic orientation decision.

2.3 Related MCDM approach

MCDM refers to methods for decision making in realistic and common scenarios in which multiple, often conflicting criteria must be taken into consideration. Many problems are related to the evaluation, measurement, selection, improvement, design and of organizational initiatives. MCDM is to analyze gaps between objectives and associated aspiration levels. In this approach, we illustrated several important aspects of and new trends in MCDM method (See Figure 3). The influential network relation map could help decision makers understand the relationships among contexts and criteria and thus enable them to propose sound strategies for improvement. This goal could be accomplished with additive or super-additive strategy based on the DEMATEL technique. A new hybrid MCDM method [43] has been developed applying the DEMATEL technique and DANP (DEMATEL-based ANP, called DANP). Several methods based on the INRM can be used to evaluate problems and enhance aspiration level achievement, including additive (e.g., VIKOR and grey relation method) and non-additive (also referred to as super-additive e.g., Fuzzy Integrals) [44] combined MCDM models. The INRM can be derived using a variety of techniques, including DEMATEL [45], Interpretive Structural Modeling (ISM) [46], Fuzzy Cognitive Map (FCM) [47], Structural Equation Modeling (SEM) [48], and Formal Concept Analysis (FCA) [49]. Current MCDM-related trends are toward the determination of how to establish strategic systems to reduce the gaps between existing performance values and aspiration levels for each criterion (such this study). Additional points of interest include the improvement and selection of the best option for decision making in new theories (e.g., DANP) and the application of these hybrid MCDM methods to real problems.

3. Evaluation Model for Environmental Strategic Orientation for Green Innovation

In this section, based on the basic concept of overall systems and algorithms for fuzzy hybrid MCDM model (See Figure 2) to develop an environmental strategic orientations evaluation model for green innovation performance, we use expert questionnaires to ascertain the determinants of the strategic orientation perspective in fuzzy environment. From the questionnaire, to overcome the response questionnaires with human judgments of perception in natural language by the vague knowledge of experts, so we use fuzzy DEMATEL technique to establish the cause-and-effect relationship for each dimension/criterion and explore the relevance of the parameters estimated from questionnaires. We apply a new fuzzy DANP approach, combining fuzzy DEMATEL and DANP, and determine the influential weights of environmental strategic orientation criteria. Ou Yang et al. propose this method to solve problems in interdependence and feedback. They employ the VIKOR method to identify gaps for improving the technology diffusion process [50, 51]. Based on the cause and effect relationship and the gaps found, we can improve the scores of the green innovation performance in fuzzy environment.

The following section contains three subsections. In section 3.1, we develop network relationships using fuzzy DEMATEL. In section 3.2, we calculate influential weights using fuzzy DANP. In section 3.3, we identify gap values for improving environmental strategic orientation with the VIKOR method based on the influential relationship map.

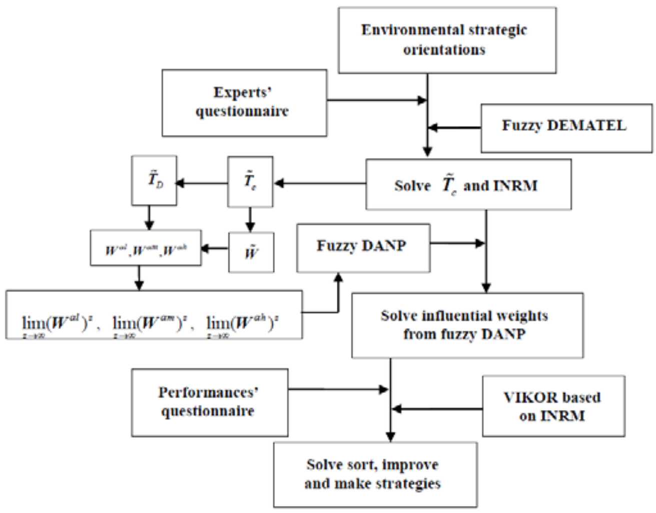

Figure 2. Basic concept of overall systems and algorithms for fuzzy hybrid MCDM.

3.1 Fuzzy DEMATEL technique for building an influential relations-map (IRM)

Fuzzy set theory can be efficiently dealt with the vagueness of human thought and expression in making decisions. To tackle the ambiguities involved in the process of decision making, the linguistic terms can be more effective in estimation. A linguistic variable is a variable whose values have the form of phrases or sentences in a natural language [52]. The linguistic variables are used as variables whose values are not numbers but linguistic terms, and can effectively described the quantitative expressions [53-57]. The linguistic term approach is a natural and effective way for decision makers to express their assessments. In practice, linguistic values can be represented by fuzzy numbers, and the triangular fuzzy number is commonly used.

DEMATEL technique is an analytical technique of structural model. It is mainly used to solve all kinds of

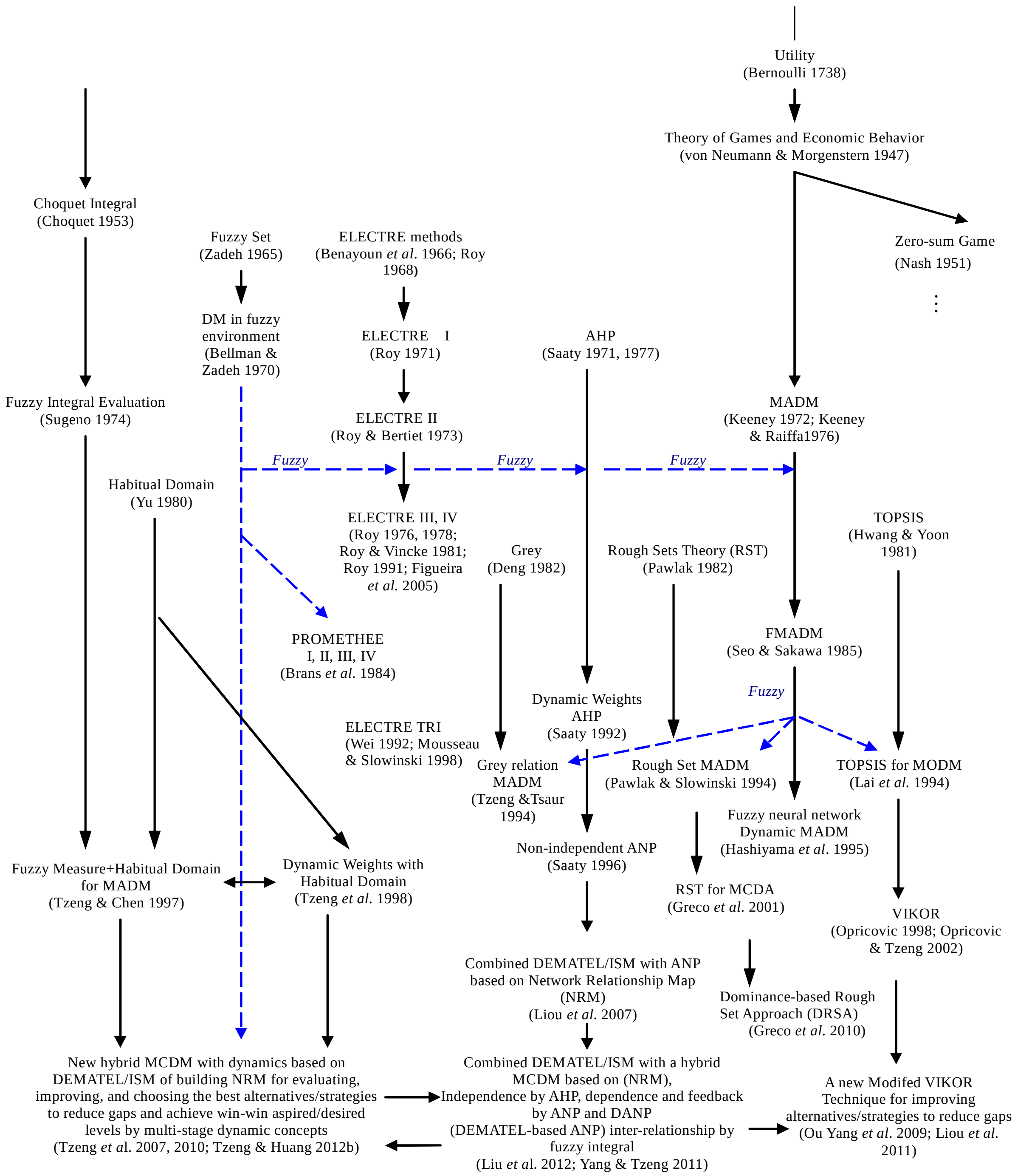

Figure 3. The development of MCDM.

complex problems to clarify the essential of the problems. It uses matrix and related math theories to find the cause and effect on each element in the influential degree. This technique is widely used to solve various types of complex studies that can effectively understand the complex structure and provide various options of problem-solving [45, 58-63]. Therefore, in this study we combined the fuzzy set theory and DEMATEL to become fuzzy DEMATEL technique. The structure of fuzzy DEMATEL and the steps of calculation are described as the following.

Step 1: Calculating the direct-influence matrix using the fuzzy linguistic scores

The experts are asked to indicate the direct effect that they believe factor i will have on factor j as indicated by fuzzy $\tilde{a}_{ij} = (l_{ij}, m_{ij}, h_{ij})$. The matrix $\tilde{\boldsymbol{A}}$ of direct relations thus can be obtained.

In the fuzzy DEMATEL formulation, respondents indicate the degree of direct influence on a scale of approximate $\tilde{0}$, $\tilde{1}$, $\tilde{2}$, $\tilde{3}$ and $\tilde{4}$, "complete no influence ($\tilde{0}$)", "low influence ($\tilde{1}$)", "medium influence ($\tilde{2}$)", "high influence ($\tilde{3}$)" and "very high influence ($\tilde{4}$)" that are expressed in positive triangular fuzzy numbers as shown in Table 2 [62].

Table 2. Linguistic scales for the importance weight of criteria (as example).

Linguistic variables	Corresponding triangular fuzzy numbers
no effect ($\tilde{0}$)	(0, 0, 0.25)
low effect ($\tilde{1}$)	(0, 0.25, 0.5)
medium effect ($\tilde{2}$)	(0.25, 0.5, 0.75)
high effect ($\tilde{3}$)	(0.5, 0.75, 1)
extremely high effect ($\tilde{4}$)	(0.75, 1, 1)

Step 2: Normalizing the direct-influence matrix

Based on the direct-influence of matrix $\tilde{\boldsymbol{A}}$ using summation h_{ij} for i and j respectively, the normalized direct-relation matrix $\tilde{\boldsymbol{D}}$ is acquired using Eqs. (1) and (2).

$$\tilde{\boldsymbol{D}} = k\tilde{\boldsymbol{A}} \tag{1}$$

$$k = \min\left\{1/\max_i \sum_{j=1}^{n} h_{ij}, 1/\max_j \sum_{i=1}^{n} h_{ij}\right\}, \quad i, j \in \{1, 2, ..., n\} \tag{2}$$

Step 3: Attaining the total-influence matrix $\tilde{\boldsymbol{T}}$

Once the normalized direct-influence matrix $\tilde{\boldsymbol{D}}$ is obtained, the total-influence matrix $\tilde{\boldsymbol{T}} = (\boldsymbol{T}^l, \boldsymbol{T}^m, \boldsymbol{T}^h)$ of IRM can be obtained using Eq. (3), in which $\boldsymbol{I}$ denotes the identity matrix.

$$\begin{aligned}\tilde{\boldsymbol{T}} &= \tilde{\boldsymbol{D}} + \tilde{\boldsymbol{D}}^2 + \tilde{\boldsymbol{D}}^3 + ... + \tilde{\boldsymbol{D}}^\phi \\ &= \tilde{\boldsymbol{D}}(\boldsymbol{I} + \tilde{\boldsymbol{D}} + \tilde{\boldsymbol{D}}^2 + ... + \tilde{\boldsymbol{D}}^{\phi-1})[(\boldsymbol{I} - \boldsymbol{D})(\boldsymbol{I} - \boldsymbol{D})^{-1}] \\ &= \tilde{\boldsymbol{D}}(\boldsymbol{I} - \tilde{\boldsymbol{D}}^\phi)(\boldsymbol{I} - \tilde{\boldsymbol{D}})^{-1}\end{aligned}$$

Then,

$$\tilde{\boldsymbol{T}} = \tilde{\boldsymbol{D}}(\boldsymbol{I} - \tilde{\boldsymbol{D}})^{-1}, \text{ when } \phi \to \infty, \quad \tilde{\boldsymbol{D}}^\phi = [0]_{n\times n} \tag{3}$$

where $\tilde{\boldsymbol{D}} = [\tilde{d}_{ij}]_{n\times n} = [(d_{ij}^l, d_{ij}^m, d_{ij}^h)]_{n\times n}$, $0 \le \tilde{d}_{ij} < 1$, $0 < \sum_{j=1}^{n} d_{ij}^h \le 1$, $0 < \sum_{i=1}^{n} d_{ij}^h \le 1$. If at least one row or column of summation is equal to 1 (but not all) in $\sum_{j=1}^{n} d_{ij}^h$ and $\sum_{i=1}^{n} d_{ij}^h$, then we can guarantee $\lim_{\phi\to\infty} \boldsymbol{D}^\phi = [0]_{n\times n}$. Then $\tilde{\boldsymbol{T}} = [\tilde{t}_{ij}]$ can be attained.

Step 4: Analyzing the results

In this stage, the sum of fuzzy rows $\sum_{j=1}^{n} \tilde{t}_{ij} = \tilde{t}_i$ and the sum of fuzzy columns $\sum_{i=1}^{n} \tilde{t}_{ij} = \tilde{t}_j$ are separately expressed as fuzzy vector $\tilde{\boldsymbol{r}} = (\tilde{r}_1, ..., \tilde{r}_i, ..., \tilde{r}_n)'$ and fuzzy vector $\tilde{\boldsymbol{c}} = (\tilde{c}_1, ..., \tilde{c}_j, ..., \tilde{c}_n)'$ by using Eqs. (4), (5), and (6). Let $i = j$ and $i, j \in \{1, 2, ..., n\}$; the horizontal axis fuzzy vector $(\tilde{\boldsymbol{r}} + \tilde{\boldsymbol{c}})$ is then created by adding $\tilde{\boldsymbol{r}}$ to $\tilde{\boldsymbol{c}}$, which illustrates the importance of the criterion. Similarly, the vertical axis fuzzy vector $(\tilde{\boldsymbol{r}} - \tilde{\boldsymbol{c}})$ is constructed by deducting $\tilde{\boldsymbol{r}}$ from $\tilde{\boldsymbol{c}}$, which may separate criteria into a cause group and an effect group. In general, when $(\tilde{\boldsymbol{r}} - \tilde{\boldsymbol{c}})$ is positive, the criterion is part of the cause group. In contrast, if vector $(\tilde{\boldsymbol{r}} - \tilde{\boldsymbol{c}})$ is negative, the criterion is part of the effect group. Therefore, the causal graph can be achieved by mapping the dataset of fuzzy vectors $(\tilde{\boldsymbol{r}} + \tilde{\boldsymbol{c}}, \tilde{\boldsymbol{r}} - \tilde{\boldsymbol{c}})$, providing a valuable approach to decision making.

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

$$\tilde{\boldsymbol{r}} = \left[\sum_{j=1}^{n} \tilde{t}_{ij}\right]_{n\times 1} = \left[\tilde{t}_{i\cdot}\right]_{n\times 1} = (\tilde{r}_1, ..., \tilde{r}_i, ..., \tilde{r}_n)' \tag{5}$$

$$\tilde{\boldsymbol{c}} = \left[\sum_{i=1}^{n} \tilde{t}_{ij}\right]'_{1\times n} = [\tilde{t}_{\cdot j}]_{n\times 1} = (\tilde{c}_1, ..., \tilde{c}_j, ..., \tilde{c}_n)' \tag{6}$$

where fuzzy vector $\tilde{\boldsymbol{r}}$ and fuzzy vector $\tilde{\boldsymbol{c}}$ express the sum of the rows and the sum of the columns from total fuzzy influence matrix $\tilde{\boldsymbol{T}} = [\tilde{t}_{ij}]_{n\times n}$, respectively, and the use of superscript denotes transpose.

3.2 Finding the influential weights of fuzzy DANP

We not only use the fuzzy DEMATEL technique to confirm the interacting relationship between each factor/criterion, but also to obtain the most accurate influential weights. The traditional ANP solves the problems with interdependence and feedback of factors/criteria. Therefore, we use these basic ANP concepts [64] as a base and combine them with fuzzy DEMATEL to solve these problems. So, fuzzy DANP (DEMATEL-based ANP) contains the following steps [62, 64]. The first step develops the influential expert questionnaire structure. The questionnaires are clearly described and broken down to the level structure. The second step develops an unweighted supermatrix, normalizing each context (dimension/cluster) with the total degree of influence obtained from the total influence matrix $\tilde{T}$ using fuzzy DEMATEL technique, shown in Eq. (7).

$$\tilde{\boldsymbol{T}}_C = \begin{array}{cc} & \begin{matrix} D_1 & & D_j & & D_n \\ c_{11}\cdots c_{1m_1} & \cdots & c_{j1}\cdots c_{jm_j} & \cdots & c_{n1}\cdots c_{nm_n}\end{matrix} \\ \begin{matrix} D_1 \begin{matrix} c_{11}\\c_{12}\\ \vdots \\ c_{1m_1}\end{matrix} \\ \vdots \\ D_i \begin{matrix}c_{i1}\\c_{i2}\\\vdots\\c_{im_i}\end{matrix} \\ \vdots \\ D_n \begin{matrix}c_{n1}\\c_{n2}\\\vdots\\c_{nm_n}\end{matrix}\end{matrix} & \begin{bmatrix} \tilde{\boldsymbol{T}}_c^{11} & \cdots & \tilde{\boldsymbol{T}}_c^{1j} & \cdots & \tilde{\boldsymbol{T}}_c^{1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{\boldsymbol{T}}_c^{i1} & \cdots & \tilde{\boldsymbol{T}}_c^{ij} & \cdots & \tilde{\boldsymbol{T}}_c^{in} \\ \vdots & & \vdots & & \vdots \\ \tilde{\boldsymbol{T}}_c^{n1} & \cdots & \tilde{\boldsymbol{T}}_c^{nj} & \cdots & \tilde{\boldsymbol{T}}_c^{nn}\end{bmatrix}\end{array} = (\boldsymbol{T}_C^l, \boldsymbol{T}_C^m, \boldsymbol{T}_C^h) \tag{7}$$

The normalized $\tilde{\boldsymbol{T}}_c$, with total degree of influence, provides $\tilde{\boldsymbol{T}}_c^{\alpha}$ from the contexts (dimensions/clusters) that shows in Eq. (8).

$$\tilde{\boldsymbol{T}}_C^{\alpha} = \begin{array}{cc} & \begin{matrix} D_1 & & D_j & & D_n \\ c_{11}\cdots c_{1m_1} & \cdots & c_{j1}\cdots c_{jm_j} & \cdots & c_{n1}\cdots c_{nm_n}\end{matrix} \\ \begin{matrix} D_1 \begin{matrix} c_{11}\\c_{12}\\ \vdots \\ c_{1m_1}\end{matrix} \\ \vdots \\ D_i \begin{matrix}c_{i1}\\c_{i2}\\\vdots\\c_{im_i}\end{matrix} \\ \vdots \\ D_n \begin{matrix}c_{n1}\\c_{n2}\\\vdots\\c_{nm_n}\end{matrix}\end{matrix} & \begin{bmatrix} \tilde{\boldsymbol{T}}_c^{\alpha 11} & \cdots & \tilde{\boldsymbol{T}}_c^{\alpha 1j} & \cdots & \tilde{\boldsymbol{T}}_c^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{\boldsymbol{T}}_c^{\alpha i1} & \cdots & \tilde{\boldsymbol{T}}_c^{\alpha ij} & \cdots & \tilde{\boldsymbol{T}}_c^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ \tilde{\boldsymbol{T}}_c^{\alpha n1} & \cdots & \tilde{\boldsymbol{T}}_c^{\alpha nj} & \cdots & \tilde{\boldsymbol{T}}_c^{\alpha nn}\end{bmatrix}\end{array} = (\boldsymbol{T}_C^{\alpha l}, \boldsymbol{T}_C^{\alpha m}, \boldsymbol{T}_C^{\alpha h}) \tag{8}$$

The total effect matrix had been normalized into a supermatrix according to the relying relationship in group; this allows us to obtain the unweighted supermatrix as shown in Eq. (9).

$$\tilde{\boldsymbol{W}} = (\tilde{\boldsymbol{T}}_c^{\alpha})' = \begin{array}{cc} & \begin{matrix} D_1 & & D_i & & D_n \\ c_{11}\cdots c_{1m_1} & \cdots & c_{i1}\cdots c_{im_i} & \cdots & c_{n1}\cdots c_{nm_n}\end{matrix} \\ \begin{matrix} D_1 \begin{matrix} c_{11}\\c_{12}\\ \vdots \\ c_{1m_1}\end{matrix} \\ \vdots \\ D_j \begin{matrix}c_{j1}\\c_{j2}\\\vdots\\c_{jm_j}\end{matrix} \\ \vdots \\ D_n \begin{matrix}c_{n1}\\c_{n2}\\\vdots\\c_{nm_n}\end{matrix}\end{matrix} & \begin{bmatrix} \tilde{\boldsymbol{W}}^{11} & \cdots & \tilde{\boldsymbol{W}}^{i1} & \cdots & \tilde{\boldsymbol{W}}^{n1} \\ \vdots & & \vdots & & \vdots \\ \tilde{\boldsymbol{W}}^{1j} & \cdots & \tilde{\boldsymbol{W}}^{ij} & \cdots & \tilde{\boldsymbol{W}}^{nj} \\ \vdots & & \vdots & & \vdots \\ \tilde{\boldsymbol{W}}^{1n} & \cdots & \tilde{\boldsymbol{W}}^{in} & \cdots & \tilde{\boldsymbol{W}}^{nn}\end{bmatrix}\end{array} = (\boldsymbol{W}^l, \boldsymbol{W}^m, \boldsymbol{W}^h) \tag{9}$$

The third step is to obtain the weighted supermatrix, which is the total effect relationship matrix of the dimensions matrix $\tilde{\boldsymbol{T}}_D$ as in Eq. (10). Each level and the dimensions of matrix $\tilde{\boldsymbol{T}}_D$ are normalised with the total degree of effect to obtain $\tilde{\boldsymbol{T}}_D^{\alpha}$, as shown in Eq. (11).

$$\tilde{\boldsymbol{T}}_D = \begin{bmatrix} \tilde{t}_D^{11} & \cdots & \tilde{t}_D^{1j} & \cdots & \tilde{t}_D^{1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{i1} & \cdots & \tilde{t}_D^{ij} & \cdots & \tilde{t}_D^{in} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{n1} & \cdots & \tilde{t}_D^{nj} & \cdots & \tilde{t}_D^{nn} \end{bmatrix} = (\boldsymbol{T}_D^l, \boldsymbol{T}_D^m, \boldsymbol{T}_D^h) \tag{10}$$

$$\boldsymbol{T}_D^{\alpha l} = \begin{bmatrix} t_D^{11l}/d_1^l & \cdots & t_D^{1jl}/d_1^l & \cdots & t_D^{1nl}/d_1^l \\ \vdots & & \vdots & & \vdots \\ t_D^{i1l}/d_i^l & \cdots & t_D^{ijl}/d_i^l & \cdots & t_D^{inl}/d_i^l \\ \vdots & & \vdots & & \vdots \\ t_D^{n1l}/d_n^l & \cdots & t_D^{njl}/d_n^l & \cdots & t_D^{nnl}/d_n^l \end{bmatrix} \tag{11}$$
$$= \begin{bmatrix} t_D^{\alpha 11l} & \cdots & t_D^{\alpha 1jl} & \cdots & t_D^{\alpha 1nl} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha i1l} & \cdots & t_D^{\alpha ijl} & \cdots & t_D^{\alpha inl} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha n1l} & \cdots & t_D^{\alpha njl} & \cdots & t_D^{\alpha nnl} \end{bmatrix}$$

We also can attain matrix $\boldsymbol{T}_D^{\alpha m}$, $\boldsymbol{T}_D^{\alpha h}$.

Then, the authors normalise $\boldsymbol{T}_D^{\alpha}$ into the unweighted supermatrix to obtain the weighted supermatrix as shown in Eq. (12).

$$\boldsymbol{W}^{\alpha l} = \boldsymbol{T}_D^{\alpha l}\boldsymbol{W}^l$$
$$= \begin{bmatrix} t_D^{\alpha 11l} \times \boldsymbol{W}^{11l} & \cdots & t_D^{\alpha i1l} \times \boldsymbol{W}^{i1l} & \cdots & t_D^{\alpha n1l} \times \boldsymbol{W}^{n1l} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1jl} \times \boldsymbol{W}^{1jl} & \cdots & t_D^{\alpha ijl} \times \boldsymbol{W}^{ijl} & \cdots & t_D^{\alpha njl} \times \boldsymbol{W}^{njl} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1nl} \times \boldsymbol{W}^{1nl} & \cdots & t_D^{\alpha inl} \times \boldsymbol{W}^{inl} & \cdots & t_D^{\alpha nnl} \times \boldsymbol{W}^{nnl} \end{bmatrix} \tag{12}$$

The weighted supermatrix $\boldsymbol{W}^{\alpha m}$ and $\boldsymbol{W}^{\alpha h}$ also can be attained.

The fourth step is to obtain the limit supermatrix. The weighted supermatrix is multiplied by itself multiple times to obtain the limit supermatrix (the concept based on the Markov Chain). Then, the influential weights of each criterion can be obtained by $\lim_{z\to\infty}(\boldsymbol{W}^{\alpha l})^z$, $\lim_{z\to\infty}(\boldsymbol{W}^{\alpha m})^z$, and $\lim_{z\to\infty}(\boldsymbol{W}^{\alpha h})^z$ respectively; in other word, the influential weights of ANP can be obtained and denoted by the limit supermatrix $\boldsymbol{W}^{\alpha}$ with power z (z representing any number for power). Then we adjust DANP influential weights based on the ratios of matrix $\boldsymbol{T}^l$, $\boldsymbol{T}^m$, and $\boldsymbol{T}^h$ in $\tilde{\boldsymbol{T}} = (\boldsymbol{T}^l, \boldsymbol{T}^m, \boldsymbol{T}^h)$ or based on the ratios of total degree of influence $(\tilde{\boldsymbol{r}} + \tilde{\boldsymbol{c}})$. We set summation equal 1 of medium triangle fuzzy number in influential weights, we adjust low bound and high bound ratios. Then triangle fuzzy numbers of DANP can be attained. We call this is the process of fuzzy DANP.

3.3 Evaluating the total performance by VIKOR

The VIKOR method, developed by Opricovic [65], solves MCDM problems in conflicting criteria [65-70]. This method is based on the positive-ideal (or the aspired level) and negative-ideal (or the worst level) solutions, with staying close to the positive-ideal point being preferable. The gap concept measures the proximity to the positive-ideal point. We describe the VIKOR method below.

The first step determines the values f_j^* and f_j^- in quality criterion assessment criteria. The value f_j^* represents the positive-ideal point (aspired levels in each criterion), the best score in criterion j; and f_j^- represents the negative-ideal point, the worse score in criterion j.

$$d_k^p = \left\{ \sum_{j=1}^{n} [w_j (\left| f_j^* - f_{kj} \right|) / (\left| f_j^* - f_j^- \right|)]^p \right\}^{1/p}$$

We use Eqs. (17) and (18) to obtain the results.

$f_j^* = \max_k f_{kj}, j = 1, 2, ..., n$ (traditional approach)

or setting the aspired levels (our approach), vector

$$\boldsymbol{f}^* = (f_1^*, f_2^*, \cdots, f_n^*) \tag{17}$$

$f_j^- = \min_k f_{kj}, j = 1, 2, ..., n$ (traditional approach)

or setting the worst values (our approach), vector

$$\boldsymbol{f}^- = (f_1^-, f_2^-, \cdots, f_n^-) \tag{18}$$

The second step calculates the minimal mean of the group utility S_k (minimal average gap) and maximal regret Q_k (maximal gap for all criteria or for each context of criteria). The value S_k represents the ratios of distances to the positive-ideal (the aspired level), giving the integrated/synthesized gap for all criteria. The value w_j represents the relative influential DANP criteria weights from influence matrix $\boldsymbol{T}$ by fuzzy DEMATEL technique. The value r_{kj} represents the distance ratios (gap) between the positive/negative-ideals (the aspired level and the worst value) for normalization. The value Q_k represents the maximum gap in all criterion (or each context of criteria of the k -th alternative in improvement priority. Eqs. (19) and (20) determine these values.

$$d_k^{p=1} = S_k = \sum_{j=1}^{n} w_j r_{kj} = \sum_{j=1}^{n} w_j \left(\left| f_j^* - f_{kj} \right| \right) \Big/ \left(\left| f_j^* - f_j^- \right| \right) \tag{19}$$

$$d_k^{p=\infty} = Q_k = \max_j \left\{ r_{kj} \mid j = 1, 2, ..., n \right\} \tag{20}$$

The third step obtains the comprehensive indicator R_k and its sorted results. Eq. (21) computes these values. From Eq. (17) how we can improve green innovation performance implementation to reduce the gaps for achieving aspired level based on influential network relation map (such as Fig.3).

$$R_k = v\left(S_k - S^*\right) \Big/ \left(S^- - S^*\right) + (1-v)\left(Q_k - Q^*\right) \Big/ \left(Q^- - Q^*\right) \tag{21}$$

Using the values derived from $S^* = \min_k S_k$ (traditional approach) or $S^* = 0$ (achieving the aspired level where the gap is zero, our approach), $S^- = \max_k S_k$ (traditional approach) or $S^- = 1$ (the worst situation, our approach); $Q^* = \min_k Q_k$ (traditional approach) or $Q^* = 0$ (achieving the aspired level, our approach), $Q^- = \max_k Q_k$ (traditional approach) or $Q^- = 1$ (the worst situation, our approach). So in our approach the gap for $S^* = 0$ and $S^- = 1$, $Q^* = 0$, $Q^- = 1$, we can re-write Eq.(21) as $R_k = vS_k + (1-v)Q_k$. The weight $v = 1$ only considers how we can minimize the average gap (average regret), and the weight $v = 0$ only determines how select the maximum gap for prior improvement. Generally, $v = 0.5$, but it can be adjusted depending on the situation.

4. Empirical Case of Electronics Industry for Green Innovation Performance

This section assesses the overall green innovation performance to propose environment strategic orientations using an empirical case in electronics industry. The data collected from their expert top-managers are analyzed by a new fuzzy hybrid MCDM method, and the results are presented in useful models for decision-making.

4.1 Problem descriptions

The effect of environmental strategic orientation toward green innovation for promoting the green innovation performance and increasing competitive advantage continues to garner much attention. As the electronics industry attempts to contemplate the integration of environmental practices and moves in the direction of environmental sustainability, management should extend their efforts to enhance environmental practices and green products or process designs across their strategic orientations towards green innovation performance in network relationship problems. However, choosing the strategy that provides stable performance and appropriate strategy in the electronics industries is very difficult. Moreover, there are many factors that concern managers regarding environmental strategy; consequently, it is a difficult problem for managers to evaluate and select a strategic orientation towards green innovation performance. To help managers identify the criteria for selecting an environmental strategic orientation, this research explores the criteria from the expert's point of view and constructs an environmental strategic orientation decision model.

In addition, because Taiwan is a leading country in the electronics industry, this research selected the most suitable environmental strategy for electronics industries spanning the hottest sectors of new product development performance, supply chain management performance, and customer management performance to offer electronics industry managers a reference for environmental strategic selection. To this end, this data analysis process is used to propose useful problem-solving strategies for the electronics industry in Taiwan.

4.2 Data collection

We collected data from 16 experts in the electronics industry (in consensus, significant confidence is 96.84%, more than 95%; i.e., gap error = 3.16%, smaller less 5%). Most experts had worked more than ten years in the electronics industry. We collected expert perspectives on all criteria via personal interviews and a questionnaire. We conducted expert elicitation in July 2011, and each subject required 60 to 70 minutes to complete a survey.

4.3 Constructing the influential relations-map by fuzzy DEMATEL

This study has confirmed the fuzzy DEMATEL decision-making structure, and analyzed five dimensions using fifty criteria for green innovation performance. According to the experts' evaluations, the total influential matrix $\tilde{\boldsymbol{T}}$ of criteria was obtained (Table 3) and serve to derive the influential relation in Table 4.
This effect is further illustrated in Figure 2; the priority of influence can be sequenced as D_4_D_1_D_3_D_5_D_2.

Table 3. Total influential matrix $\tilde{\boldsymbol{T}}$ of criteria.

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	0.324	0.428	0.322	0.436	0.368	0.410	0.317	0.317	0.314	0.331	0.338	0.330	0.362	0.308	0.304
C_2	0.415	0.339	0.325	0.442	0.381	0.415	0.322	0.322	0.319	0.349	0.344	0.340	0.363	0.317	0.299
C_3	0.362	0.377	0.250	0.384	0.330	0.366	0.295	0.307	0.303	0.336	0.307	0.308	0.319	0.281	0.273
C_4	0.370	0.378	0.301	0.333	0.353	0.377	0.306	0.304	0.312	0.322	0.333	0.308	0.352	0.288	0.287
C_5	0.320	0.341	0.273	0.373	0.263	0.357	0.268	0.270	0.268	0.290	0.283	0.283	0.322	0.267	0.264
C_6	0.385	0.395	0.298	0.400	0.374	0.309	0.293	0.293	0.297	0.314	0.311	0.319	0.340	0.288	0.277
C_7	0.315	0.327	0.269	0.353	0.307	0.327	0.222	0.274	0.276	0.277	0.276	0.275	0.310	0.263	0.258
C_8	0.307	0.308	0.266	0.331	0.286	0.303	0.270	0.216	0.269	0.276	0.268	0.268	0.305	0.258	0.251
C_9	0.336	0.337	0.297	0.364	0.305	0.327	0.276	0.282	0.230	0.297	0.283	0.281	0.320	0.265	0.259
C_{10}	0.382	0.393	0.344	0.409	0.348	0.382	0.309	0.312	0.318	0.273	0.315	0.321	0.351	0.297	0.288
C_{11}	0.363	0.393	0.296	0.420	0.368	0.376	0.308	0.304	0.305	0.317	0.264	0.311	0.350	0.290	0.279
C_{12}	0.345	0.353	0.298	0.375	0.327	0.348	0.284	0.282	0.283	0.298	0.302	0.243	0.323	0.276	0.271
C_{13}	0.360	0.368	0.296	0.391	0.339	0.359	0.301	0.300	0.299	0.315	0.308	0.306	0.280	0.295	0.291
C_{14}	0.302	0.306	0.254	0.324	0.288	0.302	0.259	0.270	0.263	0.278	0.264	0.264	0.298	0.207	0.265
C_{15}	0.308	0.307	0.248	0.328	0.287	0.303	0.253	0.258	0.254	0.264	0.268	0.260	0.295	0.263	0.200

Note: $\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\left|t_{ij}^{n}-t_{ij}^{n-1}\right|}{t_{ij}^{n}}\times 100\%$ = 3.16 % < 5%, where t_{ij}^{n} and t_{ij}^{n-1} denote the average influence of i criterion to j by n samples and $n-1$ samples respectively.

Table 4. Result of dimensions/criteria analysis.

Dimension / Criteria	$\tilde{r}_i$	$\tilde{c}_i$	$\tilde{r}+\tilde{c}$	$\tilde{r}-\tilde{c}$
Market orientation D_1	**1.700**	**1.653**	**3.353**	**0.047**
Customer orientation C_1	1.073	1.100	2.174	-0.027
Competitor orientation C_2	1.079	1.143	2.222	-0.065
Inter-function coordination C_3	0.988	0.897	1.885	0.092
Entrepreneurial orientation D_2	**1.584**	**1.761**	**3.345**	**-0.176**
Innovativeness C_4	1.062	1.106	2.168	-0.044
Risk taking C_5	0.993	0.989	1.982	0.003
Proactiveness C_6	1.083	1.043	2.126	0.040
Learning orientation D_3	**1.441**	**1.434**	**2.876**	**0.007**
Commitment to learning C_7	0.772	0.768	1.540	0.004
Shared vision C_8	0.755	0.772	1.528	-0.017
Open-mindedness C_9	0.789	0.776	1.565	0.013
Resource orientation D_4	**1.621**	**1.491**	**3.112**	**0.130**
Synergy C_{10}	0.909	0.888	1.797	0.021
Uniqueness C_{11}	0.892	0.881	1.772	0.011
Dynamism C_{12}	0.842	0.875	1.717	-0.032
Natural environmental orientation D_5	**1.450**	**1.458**	**2.907**	**-0.008**
Entrepreneurship C_{13}	0.866	0.873	1.739	-0.007
Corporate social responsibility C_{14}	0.770	0.765	1.535	0.005
Commitment to the natural environment C_{15}	0.758	0.756	1.514	0.002

When considering the improvement, the expert-managers all regarded resource orientation as first and agreed that the first priority for improvement should be resource orientation (D_4), which can have an influential effect on the remaining ones, market orientation (D_1), learning orientation (D_3) natural environmental orientation (D_5) and entrepreneurial orientation (D_2). The results suggest that the managers' top concern is resource orientation, including synergy (synergistic benefits across the organization); uniqueness (resource uniqueness to the organization); and dynamism (the enhancement of the organization's dynamic capabilities). The experts believe that improving these factors would produce better than other environmental strategic orientations. The network relation can also be seen as influencing each dimension. For example, within the category of resource orientation (D_4), it can be seen that synergy (C_{10}) exerts a direct effect on the remaining criteria, including uniqueness (C_{11}), and dynamism (C_{12}). Managers agree that synergy is the most influential way to improve resource orientation. Therefore, the general improvement priority can be sequenced (C_{10}) _ (C_{11}) _ (C_{12}) in resource orientation (D_4). In addition, there are sub-networks within the individual dimension. For instance,

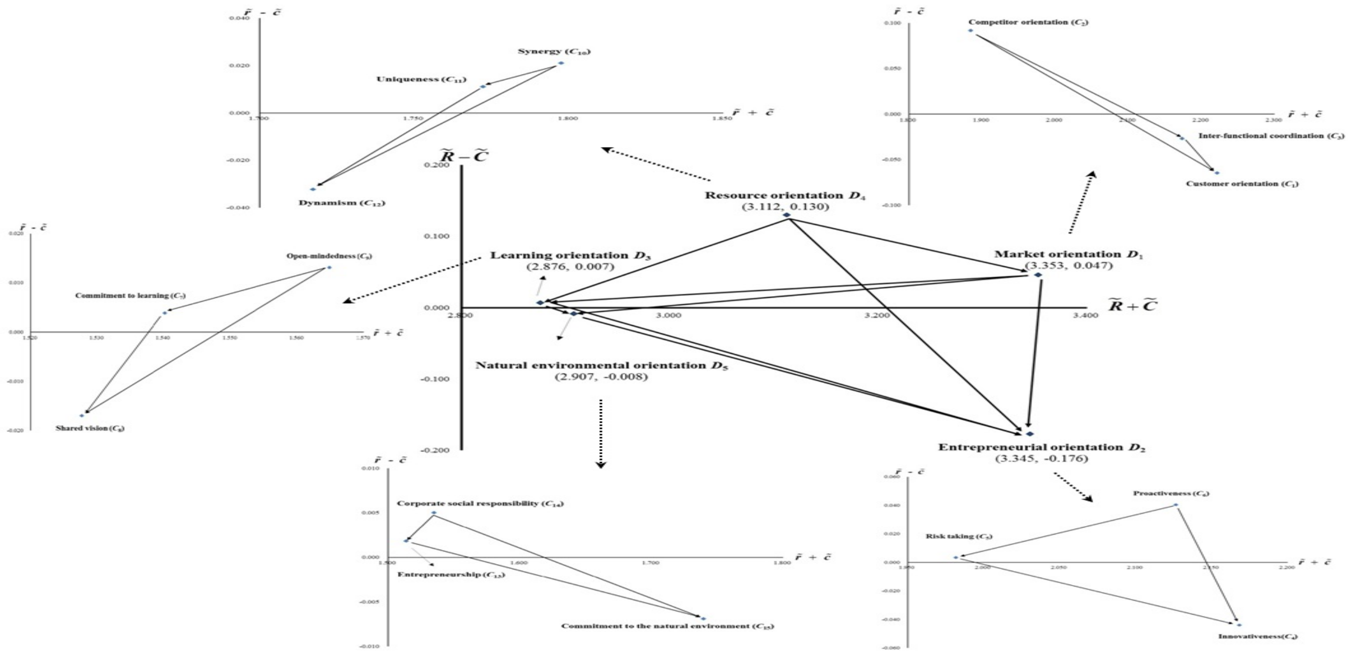

Figure 4. The INRM of relationships within the green innovation performance.

competitor orientation (C_2) produces a direct effect on inter-functional coordination (C_3) and customer orientation (C_1), indicating that the improvement priority should be (C_2) _ (C_3) _ (C_1) in market orientation (D_1); proactiveness (C_6) produces a direct effect on risk taking (C_5) and innovativeness (C_4), indicating that the improvement priority should be (C_6) _ (C_5) _ (C_4) in entrepreneurial orientation (D_2); open-mindedness (C_9) produces a direct effect on commitment to learning (C_7) and shared vision (C_8), indicating that the improvement priority should be (C_9) _ (C_7) _ (C_8) in learning orientation (D_3); corporate social responsibility (C_{14}) produces a direct effect on Entrepreneurship (C_{13}) and commitment to the natural environment (C_{15}), indicating that the improvement priority should be (C_{14}) _ (C_{13}) _ (C_{15}) in natural environmental orientation (D_5). Such an influential sub-network emerges in the individual dimension as illustrated in detail in Figure 4. For the decision-makers, this solution is not only intelligent but it also makes it easy to identify improvement priority based on complex criteria.

4.4 Calculating the influential weights by fuzzy DANP

After the fuzzy DEMATEL confirming the interfering relationship with the criteria, the research thus can proceed to obtain the most accurate weights by fuzzy DANP. Through pairwise comparisons of the unweighted supermatrix and weighted supermatrix, the limiting power of the weighted supermatrix, $\lim_{z\to\infty}(\mathbf{W}^{\alpha l})^z$, $\lim_{z\to\infty}(\mathbf{W}^{\alpha m})^z$, and $\lim_{z\to\infty}(\mathbf{W}^{\alpha h})^z$, is obtained and a steady-state condition is reached, showing the weight of each criterion (Table 5) for further analysis by VIKOR.

4.5 Discussions and implications

Using the scores derived by fuzzy DANP, the overall green innovation performance of gap can be obtained by VIKOR, as shown in Table 5. The decision-makers can identify the problem-solving points according to this integrated index, either from the perspective of the criteria as a whole or from the perspective of the individual dimensions.

For the overall dimensions, the priority sequence for reaching the aspired level can be determined by the weights of the gap value. In NPD performance, learning orientation (D_3) with a higher gap value of 0.337, is apparently the first dimension to be improved. This dimension is followed by resource orientation (D_4), natural environmental orientation (D_5), market orientation (D_1), entrepreneurial orientation (D_2). The entrepreneurial orientation (D_2) is the last dimension, based on its largest gap (0.205). Of all of the dimensions, these expert-electronics industry administers are most pay attention learning orientation and are the least pay attention their entrepreneurial orientation in NPD green performance. In SCM performance, learning orientation (D_1) with a largest gap value of 0.410, is apparently the first dimension to be improved. This dimension is followed by, resource orientation (D_4), natural environmental orientation (D_5), entrepreneurial orientation (D_2), market orientation (D_1). The market orientation (D_1) is the last dimension, based on its largest gap (0.253). Of all of the dimensions, these expert-electronics industry administers are most pay attention learning orientation and are the least pay attention their market orientation in SCM green performance. In CM performance, natural environmental orientation (D_5) with a low gap value of 0.434, is apparently the first dimension to be improved. This dimension is followed by, learning orientation (D_3), entrepreneurial orientation (D_2), resource orientation (D_4), learning orientation (D_3), market orientation (D_1). The market orientation (D_1) is the last dimension, based on its largest gap (0.254). These findings indicate the improvement priority sequence necessary for the overall dimensions to reach the aspired/desired level, from the most important dimension to the least important one.

Table 5. The gaps evaluation of green innovation performance by VIKOR.

Dimension / Criteria	Local weight (base on Global weight)	Global weight (base on fuzzy DANP)	**Green Innovation Gaps by VIKOR**		
			NPDP	**SCMP**	**CMP**
(D_1)	**0.215**		**0.211**	**0.253**	**0.254**
(C_1)	0.351	0.075	0.156	0.194	0.250
(C_2)	0.362	0.078	0.194	0.294	0.275
(C_3)	0.288	0.062	0.300	0.275	0.231
(D_2)	**0.231**		**0.205**	**0.348**	**0.398**
(C_4)	0.360	0.083	0.125	0.331	0.369
(C_5)	0.308	0.071	0.256	0.406	0.444
(C_6)	0.332	0.077	0.244	0.313	0.388
(D_3)	**0.178**		**0.337**	**0.410**	**0.414**
(C_7)	0.331	0.059	0.356	0.419	0.444
(C_8)	0.333	0.059	0.331	0.400	0.425
(C_9)	0.335	0.060	0.325	0.413	0.375
(D_4)	**0.191**		**0.271**	**0.375**	**0.349**
(C_{10})	0.338	0.065	0.338	0.363	0.244
(C_{11})	0.333	0.064	0.156	0.369	0.444
(C_{12})	0.328	0.063	0.319	0.394	0.363
(D_5)	**0.185**		**0.244**	**0.351**	**0.434**
(C_{13})	0.377	0.070	0.300	0.400	0.438
(C_{14})	0.315	0.058	0.244	0.319	0.444
(C_{15})	0.308	0.057	0.175	0.325	0.419
Total Gaps	-	-	**0.250**	**0.344**	**0.367**

As above analyses, using the gap values given by the panel experts, the schemes for improvement priority can be unique, and comprehensive, both from the separate context and from the overall point of view (as shown in Table 4). For decision-makers, it can be easier to understand the priorities for improvement in environmental strategic orientations for green innovation performance.

4.6 Discussions and implications

The empirical results are discussed as follows. In the first place, the dimensions and criteria of influence are calculated and illustrated using the IRM (as shown in Figure 3). Base on the degree of influence of Figure 3, the improvement priorities are sequenced as resource orientation (D_4), which can have an influential effect on the remaining dimensions, market orientation (D_1), learning orientation (D_3) natural environmental orientation (D_5) and entrepreneurial orientation (D_2). This is important point for electronics industry decision-makers. The expert-electronics industry administers recognize that the resource orientation issues should be improved first. Efforts in that direction will produce network effects on the remaining dimensions and will spontaneously resolve multiple issues. This strength of the INRM presented here is that it allows us to illustrate influential networks beyond a linear relationship, for the perspective of the dimensions or the criteria.

Secondly, the most important criterion calculated by fuzzy DANP when making environmental strategic decisions was innovativeness, weighted at 0.083. The degree to which electronics firm engages in and embraces new ideas, novelty, experimentation and creativity lead to new product, services or processes on green innovation. Electronics firm with greater innovativeness exhibits innovative behaviors consistently over time. In short, innovativeness represents electronics industry's willingness to depart from existing technologies, practices and ventures to explore new alternatives in its environmental strategic orientation. Therefore, the innovativeness criterion was the most significant factor when considering a strategy for green innovation selection in the electronics industry.

In addition, the overall gap values, as shown in Table 5, the average gaps, the compromise ranking by VIKOR showed that new product development performance is the best environmental strategic target for the electronics industry, followed by supply chain management performance and customer management performance. As aforementioned, new product development aims to create solutions that customers need and want [12]. To develop unique and successful products, firms need better capabilities for acting on those insights [71]. All orders must be provided by customers. Therefore, customer management performance must to be thought and promoted based on the analysis result. Customer management performance relates to the identification of strategically significant customers who are equally important to a firm. Indeed, customers differ in their value to a firm, and focusing on high-value customers will lead to retention of the right customers. High-value customers are those that bring in high revenues and profitability streams for the electronics industry.

For environmental strategic orientation improvement, the decision makers should manage this inner motivation carefully, as mentioned above. Given the empirical findings, these results as holistically formulated in Table 6, fulfill the purpose of this study. The evaluation of environmental strategic orientations for green innovation performance model provided by this study can be extended to most of the electronics industries for the using the environmental strategic orientation in fuzzy environment. There are caveats that electronics industry administrators should bear some cautions in mind when applying this model: the importance of the 15 criteria may vary according to the situation and administrators should compare evaluated the strategic orientations for green innovation performance and know what is the gap before making the optimal strategy decision in green innovation performance.

5. Conclusions

This study modeled the improvement environmental strategic orientations that should be pursued as part of green innovation performance in fuzzy environment. A novel fuzzy hybrid MCDM method was used to address dependent relationships among the various criteria together with fuzzy DEMATEL (used to construct the IRM), the fuzzy DANP (used to decide the influential weights of the criteria) and VIKOR (used to determine the improvement priority in reducing gaps). Of the various evaluations of green innovation performance in this study, those provided by the domain experts, the experienced top managers, produced useful results.

The implications of these results for management and improvement strategic orientations were presented in Table 6. The underlying concepts applied here are found to be relevant to decision-makers and top managers as well, and the computation required is straightforward and simple, using the Excel program. Most importantly, the findings can help conventional electronics industry use environmental strategic orientation planning as a means of gaining a competitive advantage in the segmented market of green innovation performance and in an increasingly uncertain, dynamic and complex world. This empirical test of our study, conducted using a case study of electronics industry, illustrated the usefulness of the approach in dealing with complex environmental strategic orientation and the meaningful implications of our study for decision-makers.

Table 6. Environmental strategic orientations for improving green innovation performance.

Formula	**Environmental strategic orientation (sequence of improvement priority)**
F1: Influential network of dimensions	$(D_4)\_(D_1)\_(D_3)\_(D_5)\_(D_2)$
F2: Influential network of criteria within individual dimensions	$D_1:(C_2)\_(C_3)\_(C_1)$
	$D_2:(C_6)\_(C_5)\_(C_4)$
	$D_3:(C_9)\_(C_7)\_(C_8)$
	$D_4:(C_{10})\_(C_{11})\_(C_{12})$
	$D_5:(C_{14})\_(C_{13})\_(C_{15})$
F3: Sequence of dimensions to rise to aspired/desired level in green innovation performance (by gap value)	In NPD performance $(D_3)\_(D_4)\_(D_5)\_(D_1)\_(D_2)$
	In SCM performance $(D_3)\_(D_4)\_(D_5)\_(D_1)\_(D_2)$
	In CM performance $(D_5)\_(D_3)\_(D_2)\_(D_4)\_(D_1)$

Appendix

Overall algorithms were updated as the appendix step by step.

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Appendix

The initial influence matrix $\tilde{\boldsymbol{A}}$ for criteria

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	(0.000, 0.000, 0.000)	(0.641, 0.891, 0.969)	(0.297, 0.469, 0.688)	(0.531, 0.781, 0.938)	(0.313, 0.547, 0.797)	(0.516, 0.766, 0.922)	(0.266, 0.453, 0.672)	(0.266, 0.438, 0.672)	(0.250, 0.406, 0.609)	(0.250, 0.438, 0.656)	(0.344, 0.531, 0.734)	(0.313, 0.484, 0.703)	(0.344, 0.516, 0.719)	(0.266, 0.438, 0.641)	(0.281, 0.453, 0.672)
C_2	(0.563, 0.813, 0.922)	(0.000, 0.000, 0.000)	(0.281, 0.453, 0.672)	(0.531, 0.781, 0.938)	(0.391, 0.641, 0.859)	(0.500, 0.750, 0.953)	(0.281, 0.469, 0.656)	(0.266, 0.453, 0.672)	(0.234, 0.422, 0.656)	(0.375, 0.563, 0.766)	(0.359, 0.547, 0.750)	(0.359, 0.547, 0.734)	(0.297, 0.484, 0.703)	(0.297, 0.484, 0.703)	(0.203, 0.375, 0.594)
C_3	(0.344, 0.594, 0.813)	(0.391, 0.641, 0.875)	(0.000, 0.000, 0.000)	(0.313, 0.563, 0.750)	(0.234, 0.422, 0.656)	(0.344, 0.594, 0.813)	(0.250, 0.438, 0.656)	(0.344, 0.531, 0.719)	(0.313, 0.500, 0.688)	(0.500, 0.688, 0.813)	(0.266, 0.453, 0.688)	(0.297, 0.484, 0.703)	(0.172, 0.344, 0.578)	(0.203, 0.375, 0.609)	(0.188, 0.359, 0.578)
C_4	(0.375, 0.609, 0.766)	(0.375, 0.563, 0.766)	(0.219, 0.406, 0.656)	(0.000, 0.000, 0.000)	(0.375, 0.563, 0.734)	(0.375, 0.625, 0.844)	(0.297, 0.484, 0.688)	(0.266, 0.453, 0.672)	(0.344, 0.531, 0.719)	(0.313, 0.500, 0.703)	(0.453, 0.641, 0.781)	(0.250, 0.422, 0.641)	(0.391, 0.578, 0.766)	(0.203, 0.391, 0.609)	(0.266, 0.422, 0.625)
C_5	(0.172, 0.406, 0.656)	(0.313, 0.500, 0.750)	(0.188, 0.375, 0.625)	(0.438, 0.672, 0.859)	(0.000, 0.000, 0.000)	(0.469, 0.719, 0.891)	(0.172, 0.359, 0.594)	(0.188, 0.359, 0.594)	(0.188, 0.328, 0.563)	(0.250, 0.438, 0.641)	(0.219, 0.406, 0.625)	(0.250, 0.422, 0.641)	(0.375, 0.563, 0.750)	(0.219, 0.391, 0.625)	(0.234, 0.422, 0.641)
C_6	(0.500, 0.750, 0.922)	(0.516, 0.750, 0.906)	(0.219, 0.391, 0.625)	(0.406, 0.625, 0.813)	(0.531, 0.781, 0.969)	(0.000, 0.000, 0.000)	(0.203, 0.391, 0.594)	(0.188, 0.359, 0.609)	(0.219, 0.406, 0.641)	(0.250, 0.438, 0.672)	(0.266, 0.438, 0.641)	(0.359, 0.547, 0.719)	(0.297, 0.484, 0.688)	(0.219, 0.406, 0.609)	(0.188, 0.344, 0.563)
C_7	(0.203, 0.438, 0.672)	(0.250, 0.469, 0.688)	(0.203, 0.391, 0.625)	(0.328, 0.578, 0.781)	(0.234, 0.484, 0.719)	(0.266, 0.516, 0.734)	(0.000, 0.000, 0.000)	(0.250, 0.438, 0.672)	(0.281, 0.469, 0.672)	(0.188, 0.375, 0.609)	(0.219, 0.391, 0.609)	(0.219, 0.406, 0.641)	(0.328, 0.500, 0.719)	(0.234, 0.406, 0.641)	(0.234, 0.406, 0.641)
C_8	(0.250, 0.422, 0.656)	(0.188, 0.359, 0.594)	(0.250, 0.422, 0.641)	(0.250, 0.438, 0.672)	(0.172, 0.359, 0.594)	(0.188, 0.359, 0.594)	(0.297, 0.484, 0.703)	(0.000, 0.000, 0.000)	(0.281, 0.469, 0.688)	(0.250, 0.422, 0.656)	(0.219, 0.391, 0.625)	(0.234, 0.406, 0.641)	(0.344, 0.531, 0.766)	(0.250, 0.438, 0.656)	(0.234, 0.422, 0.625)
C_9	(0.297, 0.547, 0.781)	(0.234, 0.484, 0.734)	(0.344, 0.594, 0.813)	(0.344, 0.594, 0.797)	(0.156, 0.406, 0.641)	(0.188, 0.438, 0.688)	(0.234, 0.406, 0.641)	(0.266, 0.453, 0.688)	(0.000, 0.000, 0.000)	(0.297, 0.484, 0.688)	(0.203, 0.391, 0.625)	(0.219, 0.391, 0.625)	(0.344, 0.531, 0.750)	(0.188, 0.375, 0.609)	(0.203, 0.359, 0.578)
C_{10}	(0.391, 0.641, 0.828)	(0.406, 0.656, 0.859)	(0.516, 0.766, 0.906)	(0.391, 0.641, 0.828)	(0.234, 0.484, 0.719)	(0.359, 0.609, 0.813)	(0.266, 0.453, 0.688)	(0.281, 0.469, 0.672)	(0.328, 0.516, 0.719)	(0.000, 0.000, 0.000)	(0.219, 0.406, 0.641)	(0.297, 0.484, 0.703)	(0.328, 0.516, 0.719)	(0.234, 0.406, 0.625)	(0.219, 0.375, 0.594)
C_{11}	(0.313, 0.500, 0.719)	(0.469, 0.719, 0.906)	(0.172, 0.359, 0.609)	(0.547, 0.797, 0.922)	(0.453, 0.703, 0.891)	(0.344, 0.594, 0.813)	(0.297, 0.484, 0.719)	(0.250, 0.438, 0.672)	(0.266, 0.453, 0.672)	(0.250, 0.438, 0.672)	(0.000, 0.000, 0.000)	(0.250, 0.438, 0.672)	(0.359, 0.547, 0.734)	(0.203, 0.391, 0.625)	(0.172, 0.344, 0.578)
C_{12}	(0.313, 0.547, 0.750)	(0.297, 0.547, 0.750)	(0.297, 0.547, 0.766)	(0.344, 0.594, 0.813)	(0.266, 0.516, 0.750)	(0.297, 0.531, 0.750)	(0.234, 0.422, 0.656)	(0.203, 0.391, 0.625)	(0.219, 0.406, 0.625)	(0.234, 0.422, 0.656)	(0.297, 0.484, 0.719)	(0.000, 0.000, 0.000)	(0.297, 0.484, 0.703)	(0.234, 0.406, 0.625)	(0.234, 0.406, 0.625)
C_{13}	(0.375, 0.563, 0.734)	(0.359, 0.547, 0.766)	(0.250, 0.406, 0.625)	(0.375, 0.625, 0.828)	(0.328, 0.500, 0.703)	(0.328, 0.500, 0.703)	(0.313, 0.484, 0.688)	(0.297, 0.469, 0.672)	(0.297, 0.453, 0.641)	(0.313, 0.484, 0.688)	(0.281, 0.469, 0.656)	(0.281, 0.469, 0.672)	(0.000, 0.000, 0.000)	(0.328, 0.500, 0.688)	(0.328, 0.516, 0.703)
C_{14}	(0.219, 0.406, 0.641)	(0.203, 0.375, 0.609)	(0.188, 0.328, 0.547)	(0.234, 0.406, 0.609)	(0.219, 0.391, 0.609)	(0.203, 0.375, 0.594)	(0.234, 0.406, 0.625)	(0.313, 0.500, 0.703)	(0.250, 0.438, 0.641)	(0.297, 0.469, 0.672)	(0.203, 0.375, 0.594)	(0.219, 0.406, 0.609)	(0.313, 0.500, 0.703)	(0.000, 0.000, 0.000)	(0.375, 0.563, 0.734)
C_{15}	(0.297, 0.484, 0.688)	(0.219, 0.406, 0.625)	(0.156, 0.313, 0.516)	(0.281, 0.469, 0.672)	(0.219, 0.406, 0.625)	(0.234, 0.406, 0.625)	(0.203, 0.375, 0.594)	(0.234, 0.406, 0.625)	(0.219, 0.375, 0.578)	(0.203, 0.359, 0.578)	(0.250, 0.438, 0.641)	(0.219, 0.391, 0.594)	(0.313, 0.500, 0.703)	(0.328, 0.516, 0.719)	(0.000, 0.000, 0.000)

The normalized direct-influence matrix $\tilde{\boldsymbol{D}}$ for criteria

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	(0.000, 0.000, 0.000)	(0.121, 0.104, 0.086)	(0.056, 0.055, 0.061)	(0.100, 0.091, 0.084)	(0.059, 0.064, 0.071)	(0.097, 0.089, 0.082)	(0.050, 0.053, 0.060)	(0.050, 0.051, 0.060)	(0.047, 0.047, 0.054)	(0.047, 0.051, 0.058)	(0.065, 0.062, 0.065)	(0.059, 0.057, 0.063)	(0.065, 0.060, 0.064)	(0.050, 0.051, 0.057)	(0.053, 0.053, 0.060)
C_2	(0.106, 0.095, 0.082)	(0.000, 0.000, 0.000)	(0.053, 0.053, 0.060)	(0.100, 0.091, 0.084)	(0.074, 0.075, 0.077)	(0.094, 0.088, 0.085)	(0.053, 0.055, 0.058)	(0.050, 0.053, 0.060)	(0.044, 0.049, 0.058)	(0.071, 0.066, 0.068)	(0.068, 0.064, 0.067)	(0.068, 0.064, 0.065)	(0.056, 0.057, 0.063)	(0.056, 0.057, 0.063)	(0.038, 0.044, 0.053)
C_3	(0.065, 0.069, 0.072)	(0.074, 0.075, 0.078)	(0.000, 0.000, 0.000)	(0.059, 0.066, 0.067)	(0.044, 0.049, 0.058)	(0.065, 0.069, 0.072)	(0.047, 0.051, 0.058)	(0.065, 0.062, 0.064)	(0.059, 0.058, 0.061)	(0.094, 0.080, 0.072)	(0.050, 0.053, 0.061)	(0.056, 0.057, 0.063)	(0.032, 0.040, 0.052)	(0.038, 0.044, 0.054)	(0.035, 0.042, 0.052)
C_4	(0.071, 0.071, 0.068)	(0.071, 0.066, 0.068)	(0.041, 0.047, 0.058)	(0.000, 0.000, 0.000)	(0.071, 0.066, 0.065)	(0.071, 0.073, 0.075)	(0.056, 0.057, 0.061)	(0.050, 0.053, 0.060)	(0.065, 0.062, 0.064)	(0.059, 0.058, 0.063)	(0.085, 0.075, 0.070)	(0.047, 0.049, 0.057)	(0.074, 0.068, 0.068)	(0.038, 0.046, 0.054)	(0.050, 0.049, 0.056)
C_5	(0.032, 0.047, 0.058)	(0.059, 0.058, 0.067)	(0.035, 0.044, 0.056)	(0.082, 0.078, 0.077)	(0.000, 0.000, 0.000)	(0.088, 0.084, 0.079)	(0.032, 0.042, 0.053)	(0.035, 0.042, 0.053)	(0.035, 0.038, 0.050)	(0.047, 0.051, 0.057)	(0.041, 0.047, 0.056)	(0.047, 0.049, 0.057)	(0.071, 0.066, 0.067)	(0.041, 0.046, 0.056)	(0.044, 0.049, 0.057)
C_6	(0.094, 0.088, 0.082)	(0.097, 0.088, 0.081)	(0.041, 0.046, 0.056)	(0.076, 0.073, 0.072)	(0.100, 0.091, 0.086)	(0.000, 0.000, 0.000)	(0.038, 0.046, 0.053)	(0.035, 0.042, 0.054)	(0.041, 0.047, 0.057)	(0.047, 0.051, 0.060)	(0.050, 0.051, 0.057)	(0.068, 0.064, 0.064)	(0.056, 0.057, 0.061)	(0.041, 0.047, 0.054)	(0.035, 0.040, 0.050)
C_7	(0.038, 0.051, 0.060)	(0.047, 0.055, 0.061)	(0.038, 0.046, 0.056)	(0.062, 0.068, 0.070)	(0.044, 0.057, 0.064)	(0.050, 0.060, 0.065)	(0.000, 0.000, 0.000)	(0.047, 0.051, 0.060)	(0.053, 0.055, 0.060)	(0.035, 0.044, 0.054)	(0.041, 0.046, 0.054)	(0.041, 0.047, 0.057)	(0.062, 0.058, 0.064)	(0.044, 0.047, 0.057)	(0.044, 0.047, 0.057)
C_8	(0.047, 0.049, 0.058)	(0.035, 0.042, 0.053)	(0.047, 0.049, 0.057)	(0.047, 0.051, 0.060)	(0.032, 0.042, 0.053)	(0.035, 0.042, 0.053)	(0.056, 0.057, 0.063)	(0.000, 0.000, 0.000)	(0.053, 0.055, 0.061)	(0.047, 0.049, 0.058)	(0.041, 0.046, 0.056)	(0.044, 0.047, 0.057)	(0.065, 0.062, 0.068)	(0.047, 0.051, 0.058)	(0.044, 0.049, 0.056)
C_9	(0.056, 0.064, 0.070)	(0.044, 0.057, 0.065)	(0.065, 0.069, 0.072)	(0.065, 0.069, 0.071)	(0.029, 0.047, 0.057)	(0.035, 0.051, 0.061)	(0.044, 0.047, 0.057)	(0.050, 0.053, 0.061)	(0.000, 0.000, 0.000)	(0.056, 0.057, 0.061)	(0.038, 0.046, 0.056)	(0.041, 0.046, 0.056)	(0.065, 0.062, 0.067)	(0.035, 0.044, 0.054)	(0.038, 0.042, 0.052)
C_{10}	(0.074, 0.075, 0.074)	(0.076, 0.077, 0.077)	(0.097, 0.089, 0.081)	(0.074, 0.075, 0.074)	(0.044, 0.057, 0.064)	(0.068, 0.071, 0.072)	(0.050, 0.053, 0.061)	(0.053, 0.055, 0.060)	(0.062, 0.060, 0.064)	(0.000, 0.000, 0.000)	(0.041, 0.047, 0.057)	(0.056, 0.057, 0.063)	(0.062, 0.060, 0.064)	(0.044, 0.047, 0.056)	(0.041, 0.044, 0.053)
C_{11}	(0.059, 0.058, 0.064)	(0.088, 0.084, 0.081)	(0.032, 0.042, 0.054)	(0.103, 0.093, 0.082)	(0.085, 0.082, 0.079)	(0.065, 0.069, 0.072)	(0.056, 0.057, 0.064)	(0.047, 0.051, 0.060)	(0.050, 0.053, 0.060)	(0.047, 0.051, 0.060)	(0.000, 0.000, 0.000)	(0.047, 0.051, 0.060)	(0.068, 0.064, 0.065)	(0.038, 0.046, 0.056)	(0.032, 0.040, 0.052)
C_{12}	(0.059, 0.064, 0.067)	(0.056, 0.064, 0.067)	(0.056, 0.064, 0.068)	(0.065, 0.069, 0.072)	(0.050, 0.060, 0.067)	(0.056, 0.062, 0.067)	(0.044, 0.049, 0.058)	(0.038, 0.046, 0.056)	(0.041, 0.047, 0.056)	(0.044, 0.049, 0.058)	(0.056, 0.057, 0.064)	(0.000, 0.000, 0.000)	(0.056, 0.057, 0.063)	(0.044, 0.047, 0.056)	(0.044, 0.047, 0.056)
C_{13}	(0.071, 0.066, 0.065)	(0.068, 0.064, 0.068)	(0.047, 0.047, 0.056)	(0.071, 0.073, 0.074)	(0.062, 0.058, 0.063)	(0.062, 0.058, 0.063)	(0.059, 0.057, 0.061)	(0.056, 0.055, 0.060)	(0.056, 0.053, 0.057)	(0.059, 0.057, 0.061)	(0.053, 0.055, 0.058)	(0.053, 0.055, 0.060)	(0.000, 0.000, 0.000)	(0.062, 0.058, 0.061)	(0.062, 0.060, 0.063)
C_{14}	(0.041, 0.047, 0.057)	(0.038, 0.044, 0.054)	(0.035, 0.038, 0.049)	(0.044, 0.047, 0.054)	(0.041, 0.046, 0.054)	(0.038, 0.044, 0.053)	(0.044, 0.047, 0.056)	(0.059, 0.058, 0.063)	(0.047, 0.051, 0.057)	(0.056, 0.055, 0.060)	(0.038, 0.044, 0.053)	(0.041, 0.047, 0.054)	(0.059, 0.058, 0.063)	(0.000, 0.000, 0.000)	(0.071, 0.066, 0.065)
C_{15}	(0.056, 0.057, 0.061)	(0.041, 0.047, 0.056)	(0.029, 0.036, 0.046)	(0.053, 0.055, 0.060)	(0.041, 0.047, 0.056)	(0.044, 0.047, 0.056)	(0.038, 0.044, 0.053)	(0.044, 0.047, 0.056)	(0.041, 0.044, 0.052)	(0.038, 0.042, 0.052)	(0.047, 0.051, 0.057)	(0.041, 0.046, 0.053)	(0.059, 0.058, 0.063)	(0.062, 0.060, 0.064)	(0.000, 0.000, 0.000)

The total influence matrix $\tilde{\boldsymbol{T}} = (\boldsymbol{T}^l, \boldsymbol{T}^m, \boldsymbol{T}^h)$ for criteria

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	(0.246, 0.272, 0.453)	(0.367, 0.372, 0.543)	(0.239, 0.268, 0.459)	(0.370, 0.382, 0.558)	(0.278, 0.315, 0.510)	(0.335, 0.357, 0.539)	(0.233, 0.264, 0.452)	(0.234, 0.263, 0.456)	(0.234, 0.263, 0.456)	(0.252, 0.277, 0.464)	(0.265, 0.284, 0.465)	(0.255, 0.275, 0.461)	(0.294, 0.303, 0.490)	(0.226, 0.256, 0.442)	(0.225, 0.252, 0.435)
C_2	(0.343, 0.363, 0.537)	(0.262, 0.283, 0.472)	(0.239, 0.271, 0.465)	(0.372, 0.388, 0.566)	(0.293, 0.329, 0.522)	(0.335, 0.361, 0.549)	(0.238, 0.270, 0.458)	(0.236, 0.269, 0.462)	(0.236, 0.269, 0.462)	(0.274, 0.294, 0.479)	(0.269, 0.290, 0.473)	(0.264, 0.286, 0.470)	(0.289, 0.305, 0.496)	(0.232, 0.265, 0.453)	(0.214, 0.248, 0.435)
C_3	(0.269, 0.315, 0.503)	(0.287, 0.325, 0.518)	(0.162, 0.201, 0.386)	(0.291, 0.336, 0.524)	(0.229, 0.281, 0.481)	(0.269, 0.317, 0.511)	(0.203, 0.246, 0.435)	(0.220, 0.256, 0.443)	(0.220, 0.256, 0.443)	(0.264, 0.285, 0.460)	(0.220, 0.257, 0.445)	(0.223, 0.258, 0.445)	(0.230, 0.265, 0.461)	(0.188, 0.233, 0.424)	(0.183, 0.226, 0.412)
C_4	(0.289, 0.321, 0.500)	(0.302, 0.323, 0.510)	(0.211, 0.250, 0.441)	(0.255, 0.281, 0.462)	(0.269, 0.302, 0.487)	(0.290, 0.326, 0.514)	(0.223, 0.255, 0.438)	(0.219, 0.252, 0.440)	(0.219, 0.252, 0.440)	(0.245, 0.270, 0.452)	(0.265, 0.282, 0.453)	(0.227, 0.256, 0.440)	(0.283, 0.296, 0.477)	(0.200, 0.239, 0.424)	(0.208, 0.237, 0.416)
C_5	(0.218, 0.273, 0.470)	(0.250, 0.288, 0.486)	(0.176, 0.224, 0.420)	(0.286, 0.323, 0.510)	(0.169, 0.214, 0.405)	(0.267, 0.308, 0.496)	(0.173, 0.220, 0.412)	(0.176, 0.220, 0.415)	(0.176, 0.220, 0.415)	(0.202, 0.240, 0.427)	(0.194, 0.235, 0.422)	(0.196, 0.233, 0.421)	(0.243, 0.269, 0.455)	(0.175, 0.218, 0.407)	(0.175, 0.216, 0.400)
C_6	(0.306, 0.335, 0.513)	(0.322, 0.341, 0.521)	(0.208, 0.247, 0.439)	(0.323, 0.348, 0.531)	(0.292, 0.323, 0.506)	(0.223, 0.258, 0.446)	(0.204, 0.244, 0.431)	(0.202, 0.241, 0.436)	(0.202, 0.241, 0.436)	(0.231, 0.262, 0.450)	(0.231, 0.260, 0.443)	(0.243, 0.268, 0.447)	(0.263, 0.285, 0.471)	(0.200, 0.240, 0.425)	(0.192, 0.228, 0.412)
C_7	(0.207, 0.271, 0.468)	(0.223, 0.279, 0.479)	(0.168, 0.222, 0.418)	(0.251, 0.308, 0.502)	(0.196, 0.262, 0.463)	(0.217, 0.281, 0.481)	(0.130, 0.176, 0.360)	(0.176, 0.225, 0.419)	(0.176, 0.225, 0.419)	(0.179, 0.230, 0.423)	(0.181, 0.229, 0.418)	(0.178, 0.227, 0.419)	(0.222, 0.258, 0.451)	(0.167, 0.216, 0.407)	(0.166, 0.212, 0.398)
C_8	(0.212, 0.256, 0.454)	(0.210, 0.255, 0.458)	(0.175, 0.216, 0.407)	(0.235, 0.279, 0.479)	(0.182, 0.237, 0.440)	(0.202, 0.252, 0.457)	(0.182, 0.220, 0.407)	(0.130, 0.167, 0.351)	(0.130, 0.167, 0.351)	(0.188, 0.224, 0.415)	(0.179, 0.218, 0.408)	(0.179, 0.217, 0.407)	(0.222, 0.250, 0.442)	(0.168, 0.210, 0.397)	(0.164, 0.204, 0.386)
C_9	(0.229, 0.290, 0.488)	(0.227, 0.289, 0.494)	(0.197, 0.250, 0.442)	(0.260, 0.318, 0.514)	(0.187, 0.261, 0.467)	(0.210, 0.281, 0.489)	(0.177, 0.228, 0.423)	(0.184, 0.233, 0.430)	(0.184, 0.233, 0.430)	(0.204, 0.248, 0.439)	(0.184, 0.235, 0.429)	(0.183, 0.232, 0.428)	(0.229, 0.268, 0.463)	(0.163, 0.218, 0.413)	(0.164, 0.212, 0.402)

C_{10}	(0.292, 0.334, 0.519)	(0.306, 0.342, 0.532)	(0.262, 0.295, 0.474)	(0.321, 0.360, 0.546)	(0.243, 0.301, 0.500)	(0.287, 0.334, 0.527)	(0.218, 0.259, 0.451)	(0.222, 0.261, 0.453)	(0.222, 0.261, 0.453)	(0.191, 0.223, 0.406)	(0.225, 0.265, 0.455)	(0.235, 0.270, 0.458)	(0.270, 0.296, 0.487)	(0.205, 0.247, 0.438)	(0.199, 0.238, 0.426)
C_{11}	(0.273, 0.311, 0.506)	(0.310, 0.340, 0.530)	(0.198, 0.245, 0.446)	(0.343, 0.368, 0.549)	(0.277, 0.317, 0.509)	(0.280, 0.325, 0.522)	(0.219, 0.256, 0.449)	(0.211, 0.251, 0.449)	(0.211, 0.251, 0.449)	(0.229, 0.264, 0.458)	(0.182, 0.213, 0.397)	(0.222, 0.258, 0.451)	(0.272, 0.294, 0.484)	(0.195, 0.240, 0.434)	(0.188, 0.230, 0.421)
C_{12}	(0.244, 0.299, 0.492)	(0.252, 0.305, 0.502)	(0.197, 0.252, 0.444)	(0.275, 0.328, 0.523)	(0.218, 0.281, 0.482)	(0.242, 0.300, 0.500)	(0.186, 0.236, 0.430)	(0.182, 0.233, 0.431)	(0.182, 0.233, 0.431)	(0.203, 0.248, 0.442)	(0.210, 0.252, 0.442)	(0.154, 0.196, 0.380)	(0.233, 0.271, 0.466)	(0.180, 0.228, 0.420)	(0.178, 0.223, 0.411)
C_{13}	(0.284, 0.308, 0.488)	(0.293, 0.312, 0.500)	(0.213, 0.243, 0.430)	(0.314, 0.339, 0.521)	(0.256, 0.287, 0.475)	(0.278, 0.305, 0.494)	(0.223, 0.249, 0.430)	(0.222, 0.248, 0.432)	(0.222, 0.248, 0.432)	(0.241, 0.261, 0.442)	(0.232, 0.257, 0.435)	(0.229, 0.254, 0.434)	(0.210, 0.225, 0.404)	(0.219, 0.245, 0.423)	(0.217, 0.241, 0.415)
C_{14}	(0.209, 0.255, 0.443)	(0.214, 0.256, 0.449)	(0.165, 0.206, 0.391)	(0.234, 0.275, 0.464)	(0.192, 0.240, 0.431)	(0.206, 0.253, 0.447)	(0.173, 0.212, 0.393)	(0.187, 0.222, 0.402)	(0.187, 0.222, 0.402)	(0.197, 0.229, 0.407)	(0.178, 0.216, 0.397)	(0.178, 0.217, 0.396)	(0.219, 0.247, 0.428)	(0.125, 0.161, 0.333)	(0.190, 0.219, 0.387)
C_{15}	(0.220, 0.261, 0.443)	(0.216, 0.258, 0.446)	(0.157, 0.202, 0.385)	(0.240, 0.280, 0.465)	(0.191, 0.240, 0.429)	(0.210, 0.255, 0.445)	(0.165, 0.207, 0.387)	(0.172, 0.210, 0.392)	(0.172, 0.210, 0.392)	(0.179, 0.215, 0.396)	(0.184, 0.221, 0.397)	(0.176, 0.214, 0.392)	(0.217, 0.245, 0.424)	(0.182, 0.217, 0.390)	(0.122, 0.156, 0.322)

The total influence matrix $\tilde{\boldsymbol{T}}$ for criteria

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	0.324	0.428	0.322	0.436	0.368	0.410	0.317	0.317	0.314	0.331	0.338	0.330	0.362	0.308	0.304
C_2	0.415	0.339	0.325	0.442	0.381	0.415	0.322	0.322	0.319	0.349	0.344	0.340	0.363	0.317	0.299
C_3	0.362	0.377	0.250	0.384	0.330	0.366	0.295	0.307	0.303	0.336	0.307	0.308	0.319	0.281	0.273
C_4	0.370	0.378	0.301	0.333	0.353	0.377	0.306	0.304	0.312	0.322	0.333	0.308	0.352	0.288	0.287
C_5	0.320	0.341	0.273	0.373	0.263	0.357	0.268	0.270	0.268	0.290	0.283	0.283	0.322	0.267	0.264
C_6	0.385	0.395	0.298	0.400	0.374	0.309	0.293	0.293	0.297	0.314	0.311	0.319	0.340	0.288	0.277
C_7	0.315	0.327	0.269	0.353	0.307	0.327	0.222	0.274	0.276	0.277	0.276	0.275	0.310	0.263	0.258
C_8	0.307	0.308	0.266	0.331	0.286	0.303	0.270	0.216	0.269	0.276	0.268	0.268	0.305	0.258	0.251
C_9	0.336	0.337	0.297	0.364	0.305	0.327	0.276	0.282	0.230	0.297	0.283	0.281	0.320	0.265	0.259
C_{10}	0.382	0.393	0.344	0.409	0.348	0.382	0.309	0.312	0.318	0.273	0.315	0.321	0.351	0.297	0.288
C_{11}	0.363	0.393	0.296	0.420	0.368	0.376	0.308	0.304	0.305	0.317	0.264	0.311	0.350	0.290	0.279
C_{12}	0.345	0.353	0.298	0.375	0.327	0.348	0.284	0.282	0.283	0.298	0.302	0.243	0.323	0.276	0.271
C_{13}	0.360	0.368	0.296	0.391	0.339	0.359	0.301	0.300	0.299	0.315	0.308	0.306	0.280	0.295	0.291
C_{14}	0.302	0.306	0.254	0.324	0.288	0.302	0.259	0.270	0.263	0.278	0.264	0.264	0.298	0.207	0.265
C_{15}	0.308	0.307	0.248	0.328	0.287	0.303	0.253	0.258	0.254	0.264	0.268	0.260	0.295	0.263	0.200

The total influence matrix $\tilde{\boldsymbol{T}}$ for dimensions

Dimensions	D_1	D_2	D_3	D_4	D_5
D_1	(0.268, 0.297, 0.482) 0.313	(0.268, 0.297, 0.482) 0.313	(0.268, 0.297, 0.482) 0.313	(0.268, 0.297, 0.482) 0.313	(0.268, 0.297, 0.482) 0.313
D_2	(0.254, 0.289, 0.478) 0.340	(0.254, 0.289, 0.478) 0.340	(0.254, 0.289, 0.478) 0.340	(0.254, 0.289, 0.478) 0.340	(0.254, 0.289, 0.478) 0.340
D_3	(0.205, 0.259, 0.456) 0.307	(0.205, 0.259, 0.456) 0.307	(0.205, 0.259, 0.456) 0.307	(0.205, 0.259, 0.456) 0.307	(0.205, 0.259, 0.456) 0.307
D_4	(0.259, 0.302, 0.494) 0.352	(0.259, 0.302, 0.494) 0.352	(0.259, 0.302, 0.494) 0.352	(0.259, 0.302, 0.494) 0.352	(0.259, 0.302, 0.494) 0.352
D_5	(0.219, 0.256, 0.442) 0.305	(0.219, 0.256, 0.442) 0.305	(0.219, 0.256, 0.442) 0.305	(0.219, 0.256, 0.442) 0.305	(0.219, 0.256, 0.442) 0.305

The sum of influences given and received on dimensions

Dimensions	$\tilde{\boldsymbol{r}}$	$\tilde{\boldsymbol{c}}$	$\tilde{\boldsymbol{r}}+\tilde{\boldsymbol{c}}$	$\tilde{\boldsymbol{r}}-\tilde{\boldsymbol{c}}$
D_1	(1.290,1.438, 2.372) 1.664	(1.206, 1.403, 2.352) 1.617	(2.495, 2.841, 4.723) 3.281	(0.084, 0.035, 0.020) 0.047
D_2	(1.162,1.331, 2.261) 1.584	(1.299, 1.513, 2.471) 1.761	(2.461, 2.844, 4.731) 3.345	(-0.138, -0.182, -0.210) -0.176
D_3	(0.956,1.200, 2.169) 1.441	(0.997, 1.185, 2.120) 1.434	(1.953, 2.385, 4.289) 2.876	(-0.041, 0.015, 0.049) 0.007
D_4	(1.163,1.372, 2.329) 1.621	(1.069, 1.238, 2.165) 1.491	(2.233, 2.610, 4.494) 3.112	(0.094, 0.133, 0.163) 0.130
D_5	(1.034,1.204, 2.111) 1.450	(1.034, 1.206, 2.134) 1.458	(2.068, 2.409, 4.245) 2.907	(0.000, -0.002, -0.022) -0.008

The novel unweighted supermatrix $\tilde{\boldsymbol{W}}$

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	(0.289, 0.298, 0.311)	(0.431, 0.408, 0.373)	(0.280, 0.294, 0.315)	(0.376, 0.362, 0.347)	(0.283, 0.299, 0.317)	(0.341, 0.339, 0.335)	(0.331, 0.335, 0.334)	(0.332, 0.333, 0.337)	(0.336, 0.331, 0.329)	(0.327, 0.331, 0.334)	(0.343, 0.340, 0.335)	(0.327, 0.329, 0.330)	(0.395, 0.374, 0.358)	(0.303, 0.316, 0.323)	(0.302, 0.310, 0.318)
C_2	(0.407, 0.396, 0.364)	(0.310, 0.309, 0.320)	(0.283, 0.296, 0.315)	(0.372, 0.360, 0.346)	(0.293, 0.306, 0.319)	(0.335, 0.335, 0.335)	(0.335, 0.335, 0.333)	(0.332, 0.333, 0.336)	(0.333, 0.331, 0.331)	(0.340, 0.338, 0.337)	(0.333, 0.333, 0.333)	(0.315, 0.322, 0.329)	(0.393, 0.373, 0.358)	(0.316, 0.324, 0.327)	(0.291, 0.303, 0.314)
C_3	(0.375, 0.374, 0.358)	(0.400, 0.387, 0.368)	(0.225, 0.239, 0.274)	(0.369, 0.360, 0.346)	(0.290, 0.301, 0.317)	(0.341, 0.340, 0.337)	(0.316, 0.325, 0.331)	(0.343, 0.339, 0.337)	(0.341, 0.336, 0.331)	(0.374, 0.356, 0.341)	(0.311, 0.322, 0.330)	(0.308, 0.317, 0.327)	(0.383, 0.367, 0.356)	(0.313, 0.321, 0.327)	(0.304, 0.312, 0.318)
C_4	(0.361, 0.359, 0.344)	(0.376, 0.361, 0.351)	(0.263, 0.279, 0.304)	(0.313, 0.309, 0.316)	(0.330, 0.332, 0.333)	(0.357, 0.359, 0.351)	(0.329, 0.332, 0.333)	(0.322, 0.328, 0.334)	(0.349, 0.340, 0.333)	(0.332, 0.334, 0.336)	(0.360, 0.349, 0.337)	(0.331, 0.329, 0.332)	(0.409, 0.383, 0.362)	(0.290, 0.310, 0.322)	(0.301, 0.307, 0.316)
C_5	(0.339, 0.348, 0.341)	(0.389, 0.367, 0.354)	(0.273, 0.285, 0.305)	(0.396, 0.382, 0.362)	(0.234, 0.254, 0.287)	(0.370, 0.364, 0.352)	(0.326, 0.334, 0.334)	(0.333, 0.334, 0.336)	(0.341, 0.331, 0.330)	(0.341, 0.339, 0.336)	(0.328, 0.331, 0.332)	(0.345, 0.339, 0.334)	(0.410, 0.382, 0.361)	(0.295, 0.310, 0.323)	(0.296, 0.308, 0.317)
C_6	(0.366, 0.363, 0.348)	(0.385, 0.370, 0.354)	(0.248, 0.268, 0.298)	(0.385, 0.375, 0.358)	(0.349, 0.348, 0.342)	(0.267, 0.278, 0.301)	(0.330, 0.334, 0.332)	(0.327, 0.329, 0.335)	(0.343, 0.337, 0.333)	(0.328, 0.332, 0.336)	(0.328, 0.329, 0.331)	(0.331, 0.332, 0.333)	(0.402, 0.378, 0.360)	(0.305, 0.319, 0.325)	(0.293, 0.303, 0.315)
C_7	(0.346, 0.351, 0.343)	(0.373, 0.361, 0.351)	(0.280, 0.288, 0.306)	(0.378, 0.361, 0.347)	(0.295, 0.308, 0.320)	(0.327, 0.331, 0.333)	(0.265, 0.279, 0.302)	(0.358, 0.357, 0.352)	(0.377, 0.364, 0.347)	(0.332, 0.335, 0.335)	(0.337, 0.334, 0.332)	(0.328, 0.329, 0.331)	(0.400, 0.376, 0.359)	(0.301, 0.315, 0.324)	(0.299, 0.309, 0.317)
C_8	(0.355, 0.353, 0.344)	(0.352, 0.350, 0.347)	(0.293, 0.297, 0.309)	(0.380, 0.363, 0.348)	(0.295, 0.308, 0.320)	(0.326, 0.328, 0.332)	(0.367, 0.363, 0.350)	(0.263, 0.275, 0.302)	(0.371, 0.362, 0.347)	(0.344, 0.340, 0.337)	(0.328, 0.331, 0.332)	(0.321, 0.324, 0.330)	(0.400, 0.376, 0.361)	(0.304, 0.316, 0.324)	(0.296, 0.307, 0.315)
C_9	(0.350, 0.350, 0.343)	(0.348, 0.349, 0.347)	(0.302, 0.302, 0.311)	(0.395, 0.369, 0.350)	(0.285, 0.303, 0.318)	(0.320, 0.327, 0.333)	(0.354, 0.353, 0.347)	(0.367, 0.362, 0.353)	(0.279, 0.285, 0.301)	(0.357, 0.347, 0.339)	(0.322, 0.329, 0.331)	(0.361, 0.356, 0.347)	(0.412, 0.384, 0.362)	(0.293, 0.313, 0.323)	(0.295, 0.304, 0.314)
C_{10}	(0.340, 0.344, 0.340)	(0.356, 0.352, 0.349)	(0.305, 0.304, 0.311)	(0.377, 0.362, 0.347)	(0.286, 0.303, 0.318)	(0.337, 0.336, 0.335)	(0.323, 0.329, 0.333)	(0.329, 0.332, 0.334)	(0.348, 0.339, 0.333)	(0.293, 0.294, 0.308)	(0.346, 0.350, 0.345)	(0.351, 0.351, 0.346)	(0.400, 0.379, 0.360)	(0.304, 0.316, 0.324)	(0.296, 0.305, 0.315)
C_{11}	(0.349, 0.347, 0.341)	(0.397, 0.379, 0.358)	(0.253, 0.274, 0.301)	(0.381, 0.364, 0.347)	(0.308, 0.314, 0.322)	(0.311, 0.321, 0.330)	(0.337, 0.336, 0.335)	(0.325, 0.330, 0.335)	(0.337, 0.334, 0.330)	(0.362, 0.359, 0.351)	(0.287, 0.290, 0.304)	(0.271, 0.281, 0.301)	(0.415, 0.385, 0.361)	(0.298, 0.314, 0.324)	(0.287, 0.301, 0.314)
C_{12}	(0.352, 0.350, 0.342)	(0.363, 0.356, 0.349)	(0.285, 0.294, 0.309)	(0.374, 0.360, 0.347)	(0.297, 0.309, 0.320)	(0.329, 0.330, 0.333)	(0.335, 0.335, 0.334)	(0.327, 0.331, 0.335)	(0.339, 0.334, 0.331)	(0.358, 0.357, 0.350)	(0.371, 0.362, 0.350)	(0.326, 0.329, 0.331)	(0.394, 0.375, 0.359)	(0.304, 0.316, 0.324)	(0.301, 0.309, 0.317)
C_{13}	(0.360, 0.357, 0.344)	(0.371, 0.361, 0.352)	(0.270, 0.282, 0.304)	(0.371, 0.365, 0.350)	(0.302, 0.308, 0.319)	(0.327, 0.327, 0.331)	(0.332, 0.335, 0.334)	(0.330, 0.333, 0.336)	(0.337, 0.332, 0.330)	(0.344, 0.338, 0.337)	(0.331, 0.333, 0.332)	(0.322, 0.328, 0.330)	(0.326, 0.317, 0.326)	(0.339, 0.344, 0.340)	(0.336, 0.339, 0.334)
C_{14}	(0.355, 0.355, 0.345)	(0.364, 0.357, 0.350)	(0.281, 0.287, 0.305)	(0.371, 0.358, 0.346)	(0.304, 0.312, 0.321)	(0.326, 0.329, 0.333)	(0.320, 0.326, 0.331)	(0.347, 0.342, 0.339)	(0.333, 0.333, 0.330)	(0.357, 0.345, 0.339)	(0.322, 0.327, 0.331)	(0.326, 0.329, 0.331)	(0.410, 0.393, 0.373)	(0.235, 0.257, 0.290)	(0.355, 0.349, 0.337)
C_{15}	(0.371, 0.362, 0.347)	(0.364, 0.358, 0.350)	(0.265, 0.280, 0.302)	(0.375, 0.361, 0.347)	(0.298, 0.310, 0.320)	(0.327, 0.329, 0.333)	(0.325, 0.331, 0.333)	(0.337, 0.337, 0.337)	(0.338, 0.333, 0.330)	(0.332, 0.331, 0.334)	(0.342, 0.340, 0.335)	(0.327, 0.329, 0.330)	(0.417, 0.397, 0.373)	(0.349, 0.351, 0.343)	(0.235, 0.252, 0.283)

Weighting the unweighted supermatrix based on total influence normalized matrix $\tilde{\boldsymbol{W}}^*$

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	(0.060, 0.062, 0.065)	(0.090, 0.085, 0.078)	(0.058, 0.061, 0.066)	(0.090, 0.087, 0.083)	(0.068, 0.071, 0.076)	(0.081, 0.081, 0.080)	(0.059, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.059, 0.058)	(0.064, 0.065, 0.066)	(0.068, 0.067, 0.066)	(0.065, 0.065, 0.065)	(0.071, 0.067, 0.064)	(0.054, 0.057, 0.058)	(0.054, 0.056, 0.057)
C_2	(0.085, 0.082, 0.076)	(0.064, 0.064, 0.067)	(0.059, 0.061, 0.066)	(0.089, 0.086, 0.083)	(0.070, 0.073, 0.076)	(0.080, 0.080, 0.080)	(0.059, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.059, 0.059, 0.059)	(0.067, 0.067, 0.066)	(0.066, 0.066, 0.065)	(0.064, 0.065, 0.065)	(0.070, 0.067, 0.064)	(0.057, 0.058, 0.059)	(0.052, 0.054, 0.056)
C_3	(0.078, 0.078, 0.074)	(0.083, 0.080, 0.077)	(0.047, 0.050, 0.057)	(0.088, 0.086, 0.083)	(0.069, 0.072, 0.076)	(0.081, 0.081, 0.081)	(0.056, 0.058, 0.059)	(0.061, 0.060, 0.060)	(0.061, 0.060, 0.059)	(0.074, 0.070, 0.067)	(0.061, 0.063, 0.065)	(0.062, 0.063, 0.065)	(0.069, 0.066, 0.064)	(0.056, 0.058, 0.059)	(0.054, 0.056, 0.057)
C_4	(0.079, 0.078, 0.075)	(0.082, 0.079, 0.077)	(0.057, 0.061, 0.066)	(0.071, 0.070, 0.072)	(0.075, 0.075, 0.076)	(0.081, 0.082, 0.080)	(0.057, 0.058, 0.058)	(0.056, 0.057, 0.058)	(0.061, 0.059, 0.058)	(0.065, 0.065, 0.065)	(0.070, 0.068, 0.066)	(0.060, 0.062, 0.064)	(0.076, 0.071, 0.067)	(0.054, 0.057, 0.060)	(0.056, 0.057, 0.059)
C_5	(0.074, 0.076, 0.075)	(0.085, 0.080, 0.077)	(0.060, 0.062, 0.067)	(0.090, 0.087, 0.082)	(0.053, 0.058, 0.065)	(0.084, 0.083, 0.080)	(0.057, 0.058, 0.058)	(0.058, 0.058, 0.059)	(0.060, 0.058, 0.058)	(0.066, 0.066, 0.065)	(0.064, 0.064, 0.065)	(0.064, 0.064, 0.065)	(0.076, 0.071, 0.067)	(0.055, 0.057, 0.060)	(0.055, 0.057, 0.059)
C_6	(0.080, 0.079, 0.076)	(0.084, 0.081, 0.077)	(0.054, 0.058, 0.065)	(0.087, 0.085, 0.081)	(0.079, 0.079, 0.078)	(0.061, 0.063, 0.068)	(0.058, 0.058, 0.058)	(0.057, 0.057, 0.059)	(0.060, 0.059, 0.058)	(0.064, 0.065, 0.065)	(0.064, 0.064, 0.064)	(0.067, 0.066, 0.065)	(0.075, 0.070, 0.067)	(0.057, 0.059, 0.060)	(0.054, 0.056, 0.058)
C_7	(0.074, 0.075, 0.074)	(0.080, 0.078, 0.075)	(0.060, 0.062, 0.066)	(0.085, 0.082, 0.078)	(0.067, 0.070, 0.072)	(0.074, 0.075, 0.075)	(0.046, 0.048, 0.052)	(0.062, 0.062, 0.061)	(0.065, 0.063, 0.060)	(0.064, 0.064, 0.065)	(0.065, 0.064, 0.064)	(0.064, 0.064, 0.064)	(0.077, 0.073, 0.070)	(0.058, 0.061, 0.063)	(0.058, 0.060, 0.061)
C_8	(0.076, 0.076, 0.074)	(0.076, 0.075, 0.075)	(0.063, 0.064, 0.066)	(0.086, 0.082, 0.079)	(0.066, 0.070, 0.072)	(0.073, 0.074, 0.075)	(0.064, 0.063, 0.061)	(0.045, 0.048, 0.052)	(0.064, 0.063, 0.060)	(0.066, 0.065, 0.065)	(0.063, 0.064, 0.064)	(0.063, 0.063, 0.064)	(0.078, 0.073, 0.070)	(0.059, 0.061, 0.063)	(0.057, 0.060, 0.061)
C_9	(0.075, 0.075, 0.074)	(0.075, 0.075, 0.075)	(0.065, 0.065, 0.067)	(0.089, 0.083, 0.079)	(0.064, 0.068, 0.072)	(0.072, 0.074, 0.075)	(0.061, 0.061, 0.060)	(0.064, 0.063, 0.061)	(0.048, 0.049, 0.052)	(0.069, 0.067, 0.065)	(0.062, 0.063, 0.064)	(0.062, 0.062, 0.064)	(0.080, 0.074, 0.070)	(0.057, 0.061, 0.063)	(0.057, 0.059, 0.061)
C_{10}	(0.076, 0.077, 0.076)	(0.079, 0.078, 0.078)	(0.068, 0.068, 0.069)	(0.090, 0.086, 0.082)	(0.068, 0.072, 0.075)	(0.080, 0.080, 0.080)	(0.058, 0.059, 0.060)	(0.059, 0.060, 0.060)	(0.062, 0.061, 0.060)	(0.052, 0.052, 0.054)	(0.061, 0.062, 0.061)	(0.064, 0.063, 0.061)	(0.073, 0.070, 0.066)	(0.056, 0.058, 0.059)	(0.054, 0.056, 0.058)
C_{11}	(0.078, 0.077, 0.076)	(0.089, 0.084, 0.080)	(0.056, 0.061, 0.067)	(0.090, 0.086, 0.082)	(0.073, 0.075, 0.077)	(0.074, 0.076, 0.078)	(0.061, 0.060, 0.060)	(0.058, 0.059, 0.060)	(0.061, 0.060, 0.059)	(0.064, 0.063, 0.062)	(0.051, 0.051, 0.054)	(0.062, 0.062, 0.061)	(0.076, 0.071, 0.066)	(0.055, 0.058, 0.059)	(0.053, 0.055, 0.058)
C_{12}	(0.078, 0.078, 0.076)	(0.081, 0.079, 0.078)	(0.063, 0.066, 0.069)	(0.089, 0.086, 0.082)	(0.071, 0.073, 0.076)	(0.078, 0.078, 0.079)	(0.060, 0.060, 0.060)	(0.059, 0.059, 0.060)	(0.061, 0.060, 0.059)	(0.063, 0.063, 0.062)	(0.066, 0.064, 0.062)	(0.048, 0.050, 0.053)	(0.072, 0.069, 0.066)	(0.056, 0.058, 0.059)	(0.055, 0.057, 0.058)
C_{13}	(0.076, 0.076, 0.073)	(0.079, 0.077, 0.075)	(0.057, 0.060, 0.064)	(0.085, 0.083, 0.080)	(0.069, 0.070, 0.073)	(0.075, 0.075, 0.076)	(0.061, 0.062, 0.062)	(0.061, 0.062, 0.062)	(0.062, 0.061, 0.061)	(0.066, 0.065, 0.065)	(0.064, 0.064, 0.064)	(0.063, 0.063, 0.064)	(0.059, 0.058, 0.059)	(0.062, 0.063, 0.062)	(0.061, 0.062, 0.061)
C_{14}	(0.075, 0.075, 0.073)	(0.077, 0.076, 0.074)	(0.060, 0.061, 0.065)	(0.084, 0.082, 0.079)	(0.069, 0.071, 0.073)	(0.074, 0.075, 0.076)	(0.059, 0.060, 0.061)	(0.064, 0.063, 0.063)	(0.062, 0.061, 0.061)	(0.069, 0.067, 0.065)	(0.062, 0.063, 0.064)	(0.062, 0.063, 0.064)	(0.075, 0.072, 0.068)	(0.043, 0.047, 0.053)	(0.065, 0.064, 0.062)
C_{15}	(0.079, 0.077, 0.074)	(0.077, 0.076, 0.074)	(0.056, 0.059, 0.064)	(0.085, 0.082, 0.079)	(0.068, 0.071, 0.073)	(0.075, 0.075, 0.076)	(0.060, 0.061, 0.061)	(0.062, 0.062, 0.062)	(0.062, 0.061, 0.061)	(0.064, 0.064, 0.064)	(0.066, 0.066, 0.065)	(0.063, 0.063, 0.064)	(0.076, 0.072, 0.068)	(0.064, 0.064, 0.063)	(0.043, 0.046, 0.052)

The stable matrix of ANP when power limit $h \to \infty$, i.e., $\lim_{h\to\infty} (\tilde{W}^*)^h$

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_2	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_3	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_4	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_5	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_6	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_7	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_8	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_9	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_{10}	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_{11}	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_{12}	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_{13}	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_{14}	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)
C_{15}	(0.076, 0.076, 0.074)	(0.080, 0.078, 0.076)	(0.059, 0.061, 0.066)	(0.086, 0.083, 0.080)	(0.069, 0.071, 0.074)	(0.076, 0.077, 0.077)	(0.058, 0.059, 0.059)	(0.059, 0.059, 0.060)	(0.060, 0.060, 0.059)	(0.065, 0.065, 0.064)	(0.064, 0.064, 0.064)	(0.062, 0.063, 0.063)	(0.073, 0.069, 0.066)	(0.056, 0.058, 0.060)	(0.055, 0.057, 0.058)

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