Applying Eco-innovation for Enhancing Corporate Functions under Chinese Management Style

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Abstract. Lots of Agri-service firm located in Panjin city, China which aggressive integrate the eco-innovation into business management function for developing the sustainable competitiveness. Although these firms have better environmental awareness, they still suffer the difficulty in evaluating the performance of eco-innovation. Hence, this study utilizes collaboration theory as theoretical basis to enhance the understanding of eco-innovation and business management integration. Subsequently, fuzzy Decision Making Trial and Evaluation Laboratory is proposed to assist firms in evaluating the performance and identify the critical factors in current implementations. In addition, the interpretive structural modeling is adopted to construct the execution guideline. The findings of this study enable to offer the precise indicators to lead Panjin Agri-service firms for improving the sustainable competitiveness.

Keywords: Eco-innovation; corporate functions; Chinese management style; fuzzy Decision Making Trial and Evaluation Laboratory; interpretive structural modeling

1. INTRODUCTION

Since the 1980s, the Ecological Footprint of human has strained the carrying capacity of the earth. A series of problems including the growing worldwide population expansion, shortage of resources, ecological degradation, environmental events and climate warming force governments to explore the way of sustainable development. Because Eco-innovation makes it possible to realize the harmonious development of economy, society, resources and environment, it gradually becomes a focus of attention for government, academic and business. Internationally when realizing technological innovation have negative effect on the natural environment, the world begins to pay close attention to Eco-innovation and international summit held many times also reflects the common wish of building a green earth. Domestically, since Chinese economic reform, China's economic development has made great achievements. At the same time, the contradiction between economic development and environment deterioration is also growing and the environment problem has become a big obstacle for the sustainable development of China's rapid economic. More and more Chinese enterprises realize that if they realize the sustainable development of the economy's long-term goal, they must be the organic integration between ecological environment management and the economic and social development and realize transformation and upgrading through the green innovation, combined with China's situation, forming suitable management style for China's enterprise.

Eco-innovation performance is viewed as a composite indicator of environmental performance, economic performance and sustainable competitiveness (Margolis & Walsh, 2003). Among them, environmental performance is the core of Eco-innovation and eco-innovation has been studied

from multiple perspective. Consumers adoption of innovation marketed is referred as to be eco-innovation in order to analyze factors explaining these two types of green behaviors (Jansson et al., 2010). Environmental performance and competitiveness are significantly influenced by different types of eco-innovation (Dong et al., 2014). The organizational eco-innovation is the most common, then followed by process eco-innovation, product eco-innovation and en-of-pipe eco-innovation. Cai and Zhou (2014) developed a conceptual model and tested on a large database of firms which come from various industries using hierarchical regression analysis. This study reveals that eco-innovation is triggered by internal and external drivers. In China, the external pressures which come from customers' green demands, environmental regulations and competitors affect eco-innovation partially through internal drivers.

Selecting the appropriate indicators is the key to the evaluation of enterprise green innovation ability. The investment cycle, rate of return on investment (RIO) and net present value are economic performance indicators and cost-benefit analysis, incorporating cash flow, and financial dynamic profitability are the tools to measure economic performance (Kemp et al., 2007a). Generally, we defined environmental performance from a micro or a macro perspective. Micro-level eco-innovation performance is a standard evaluating the legality of a firm's operations and/or comparing it with different firms (Lazaro et al., 2008). Macro-level eco-innovation performance take micro-level performance indicators into account and also considers the benefits achieved by continuous environmental improvements, among which it should focus on economic performance and competitive advantages (Boons & Wagner, 2009). But due to lacking of attention on eco-innovation features and types of environmental regulation, it is difficult to understand effects these regulations have on a firm's eco-innovation performance (Rassier & Earnhart, 2010; Costantini & Mazzanti, 2012). At t diverse the same time different regulatory measures bring complexity to the issue (Popp et al., 2011; Horbach et al., 2012). Especially in China management system is not yet perfect, it is important to choose the indicators.

It is important to integrate indicator system to measure eco-innovation performance. Zoboli (2006) stated that the measurement of eco-innovation performance should include the following four areas: R&D expenses, expenses on pollution control, production efficiency of natural materials and pollution intensity and reduction of pollutant emissions. But the research on eco - innovation measures and the sustainability performance of the business practices in developing countries is limited (Dong & Shi, 2010). Therefore, in China's text this paper reference corporate functions namely the Production, Marketing, R&D, HRM and Finance as aspects, and then to find the eco-innovation index through literature and enterprise actual research. It uses the fuzzy decision making trial and evaluation laboratory (FDEMATEL) method to identify causal indicators, and use ISM method to index layer, on the basis of the original aspects further subdivided, in order to put forward Chinese-style management structure. This paper validates the feasibility and effectiveness of the model and method with China liaoning panjin agriculture benchmarking enterprise " Jin She Yu Nong Supply and Marketing Group (LJSYN) " as an example in order to practice green innovation provides guidance for the enterprise. Literature reviews and programs measures are addressed in the following section. The detailed discussion of the methods is provided in section 3. Section 4 provides the empirical results of the research. section 5 discusses the theoretical and managerial implications and conclusions. The future research and limitations are included in the last section.

2. LITERATURE REVIEW

2.1 Eco-Innovation

It has a variety of the definition of green innovation. Eco-innovation has been broadly defined as the process of developing new ideas and behaviors, the products and the processes that contribute to a reduction in environmental burdens or to ecologically specified sustainability targets (Rennings, 2000). Hines and Marin (2004) point out that most innovation appears to build on "repurposing, improving the or renewing existing ideas and practices". Hellstrom (2007) points out that the innovation of enterprise towards a sustainable society may be conceived on three broad levels: technological, social and institutional. Kemp and Foxon (2007b) give another definition of eco-innovation that it is "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use compared to relevant alternatives". Reid and Miedzinski (2008) define eco-innovation as the creation of novel and competitively priced goods, services, systems, processes, and procedures to satisfy human needs and provide a better quality of life for everyone with a life-cycle minimal use of natural resources per unit output, and minimal release of toxic substances.

Eco-innovation research acquires the new dimension of environmental management adding complexity. For the enterprise, eco - innovation is a new concept for the company adopting it (Kemp & Arundel,2009; Kemp, 2010) and may lead to varied levels of environmental improvement. The literature on innovation for sustainability largely focuses on large companies (Bos-Brouwers, 2010). The international and domestic scholars also done a lot of research on how to innovate and innovation behavior from multiple perspectives.

Bocken et al. (2011) investigated eco-ideation processes for the research sample. Cheng et al. (2014) investigate three types of eco-innovation (process, product, organizational) and find inter-relationships between them on the basis of resource-based view theory and their relative impact on business performance. Mylan et al. (2015) investigated the effect supermarkets have on upstream eco-innovation in UK milk, beef and bread chains. Wu et al. (2015) proposed interval-valued triangular fuzzy numbers to convert the experts' opinions into comparable measures and used grey relational analysis to facilitate and clarify the weights of eco-innovation under dynamic organizational capability.

Although the concept and the emphasis studied is different, the research and design (R&D), finance, human research resource management (HRM) is the key aspects the enterprise eco- innovation consider. It is widely agreement in the literature that environmental policies have potentially strong effect on both the speed and the direction of environmental innovation. Osterhuis and ten Brink (2006) find that environmental policies can drive eco-innovation in empirical studies, but they can't get agreement on what kinds of policy instruments are best suited to support the development and diffusion of environmental technology. Przychodzen & Przychodzen (2015) explored four types of eco - innovation (product, process, market and sources of supply) and their influence on accounting-based measurers of financial performance. The findings suggest that strong asset and financial capabilities are important for the development of eco-innovativeness and that there is a need for environmental policy to create incentives. But the existing research does not have a complete index system to guide assessment. So corporate functions is particularly important because it can reflect all aspects of the comprehensive function of the enterprise. If it can evaluate function of enterprise innovation ability from multi-aspects, there is no doubt to provide more comprehensive and comprehensive help for enterprise management decision.

2.2 Corporate Functions

There are not fixed concept about corporate functions. It includes the supply chain and related departments like purchasing, logistics, production, research and development (R&D), sales and marketing (Bowen et al., 2001; Darnall et al., 2008; Seuring & Müller, 2008). In addition, other functions such as human resources HR, accounting, public relations PR, corporate finance and management control can also be involved (Shrivastava & Hart, 1995; Henri & Journeault, 2010). Zhang (2009) points out corporate function should include organization structure, human resource, corporate culture, quality, marketing, etc; Zhang (2014) analyzes three functions of enterprises (marketing, finance and HR). Schaltegger et al. (2014) investigates the difference of different corporate functions are involved in corporate sustainability management, and point out that all functions can contribute to the eco-innovation of the company, no matter whether they do this with internal activities or externally with publicly recognized measures. Kunisch et al. (2016) state briefly in Harvard business review and traditional headquarters functions contain finance, HR, IT, marketing and strategy.

There have different indicators in measuring an enterprise's eco-innovation under the different enterprises function. Predictive institutional, economic, environmental performance, policy and cultural indicators (including those based on societal values) is derived in the ECODRIVE project in order to show the occurrence of eco-innovation (Huppes et al., 2008). And in the Measuring Eco-Innovation project a list of indicators of eco-innovation covering a wide area are derived (Ekins, 2010).According to different enterprise characteristics, scholars both at home and abroad to study one or some indicators. Yu (2010) defined competitiveness as revolving around the familiarity with the relevant industry and competitors, price-based competition, and the follow-up speed of state-of-the-art technology. Ko et al. (2013) discussed managerial implications of a strategic marketing performance through building corporate images in green market for Korea. Polzin et al. (2016) explored the finance mobilization functions of institutional innovation intermediaries, and find that particular functions of institutional innovation intermediaries can partly overcome financial barriers to eco-innovation.

However, most existing literature is only using one or some indicators to analyze the evaluation of enterprise financial capability and competitiveness, etc. But there are few literatures to establish a unified corporate functions and indicators to comprehensively assess the innovation ability of enterprises, lacking in-depth discussion of Chinese-style management mode. There have significant difference between the management mode of China and other countries (especially developed countries) management model (Busch et al., 2013). At present, Eco-innovation is an important driving force to support the enterprise sustainable development (Kanda et al., 2015). And combining with China's text Chinese management mode can be more effective to guide eco-innovation behavior. As a result, it is important to put forward a set of Chinese characteristics management style to help enterprises realize the real eco-innovation.

2.3 Chinese Management Style

Li and Tsui (2002) researched the management issues in Chinese organizations. They analyzed research on 226 research articles publishing in 20 leading English language academic journals over the past 16 years (1984–1999) by performing a citation analysis. As the world's largest emerging economy, China provide a legitimate context for management research (Tsui et al., 2004). Jia et al. (2012) developed a

context-emic model to evaluate articles in Chinese context. Busch et al. (2013) analysis the difference of German employees' perception of Chinese leadership styles and German managers' method. Zhang et al. (2015) investigated the relationship among innovation performance, conflict management styles (CMSs) and emotional intelligence (EI), and test the mediating effects of various types of CMSs.

However, lacking of theory development in management practices (White, 2002) and new management theories (Tsui et al., 2004), Chinese or Asian management research is insufficient (Meyer, 2006). The research has two salient and important limitations in the Chinese context. First, most research focus on qualitative reviews and there is limited in systematic empirical evidence (Peng et al., 2001; Meyer, 2006). Second, there has no research on evaluating the contribution to management knowledge in the Chinese context using a systematic model or framework. Colquitt and Zapata-Phelan (2007) never consider the role of context using the theory-building-testing model to assess theoretical contributions of empirical articles. As Tsui (2009) says: "over two decades, research in Chinese management has exploited existing questions, theories, constructs, and methods developed in the Western context. Lagging is exploratory studies to address questions relevant to Chinese firms and to develop theories that offer meaningful explanations of Chinese phenomena".

This shows that contextualization in Chinese management is very important. There have different management modes under different culture (Lung-Tan & Yuan-Ho, 2005), and there has different effect the management mode of different countries on strategic decision (Martinsons & Davison, 2007). Some scholars aware that it is difficult to management research restricts itself to the Western model in the management discipline, and we should pay attention on contextualized studies, especially the context - specific research (Rousseau & Fried, 2001; Leung, 2007; Whetten, 2009). However, the existing literature discussing this is slightly less. It need indigenous research when the extant Western theories or constructs can't account for a unique local phenomenon (Li et al., 2012). Therefore, if you want to study Chinese enterprises eco-innovation ability and then further understand Chinese management style, it is important to do research basing on the theory of China's national conditions. It is need to combine with the actual situation of Chinese enterprises and integrate relevant indicators and methods to assess accurately the eco- innovation ability and have a better understanding of Chinese management style.

2.4 Proposed Methods

Horlings and Marsden (2011) provide accurate guidelines for eco-innovation throng special dynamic organization performance evaluation with grey relational analysis method. Cheng et al. (2014) research the relationship eco-three types of innovation (process, product, organization) and relative impact on business performance based on the point of resource theory. Zhang and Zhang (2014) research the deep factors influencing the enterprises to carry out the strategy of eco-innovation through the depth interview on the base of grounded theory, and find that three main categories (expected economic benefits, the redundant resources and stakeholders pressure) exert significant influence on eco-innovation strategy. Li and Tang (2014) empirically test the relationship of market orientation, policy guidance, enterprise eco- innovation and corporate performance by building PIES structural equation model, and find that market orientation and policy orientation has a significant positive effect on enterprise eco-innovation. Yang (2015) integrates the natural resource base theory and complementary assets theory, and empirically tests the influence eco-innovation strategy have on the enterprise value further revealing that eco-innovation strategy improve internal key ability and resources (innovation and organization redundancy) enterprise value need and its mechanism of action.

However, these studies provide research methods for the enterprise eco-innovation from the perspective of qualitative, and experts and decision makes often find it difficult to indicate their opinion as a number between 0 and 1. Cornelis et al. (2006) revealed that several studies have argued that the presentation of linguistic expressions in the form of an ordinary fuzzy set is not adequately convincing and clear. Thus, Tseng (2011a) proposing multiple criteria decision making (MCDM) model to solve the dependent relationship of the network process (ANP) and decision making experiment under the condition of uncertain to assess the environmental knowledge management ability, and find that the link characteristics of the subjective judgment and environmental practice to describe the decision criteria of environmental knowledge management ability. Shen (2012) assess purchase intention of individual green products using the five-point scale method. To enhance the quality of feasible alternatives, Baležentis and Zeng (2013) applied the interval-valued fuzzy Numbers To assess uncertainty in multi-criteria decision making. Wu et al (2016) integrate of interval-valued triangular fuzzy number and grey relational analysis (GRA) method to evaluate Taiwan's high-tech electronics industry green supply chain. In addition, Wu et al. (2016) use fuzzy expert method (FDM) and grey Delphi method (GDM) to assess supply chain uncertainty and risk. Although fuzzy method can overcome the barrier of incomplete information, there are still not clear to how to understand the characteristic of the enterprise management mode from the theoretical aspects, and need to integrate relevant methods for further research.

Warfield (1974) points out that the interpretive structural modeling (ISM) theory is based on discrete mathematics, social sciences, graph theory, group decision-making, and computer assistance. ISM can help researchers and managers deeply understand the relationship among key issues (Saxena

and Vrat, 1992). ISM can be used a qualitative tool and a modeling technique to analyze the effect of one element (Wang et al., 2008) and deeply understand these relationships and their levels. Malone makes briefly review about ISM concepts (Eswarlal et al., 2011). When dealing with complex problems encountering difficulties is common. The reason that why the issues or systems is complex is that lots of elements and interactions among these elements happen. Hence, the development of a methodology that aids in the identification of a structure within a system is necessary. ISM is this type of methodology (Attri et al., 2013). Thus, this study addresses the lack-of-information problem and identify factors influencing eco-innovation using fuzzy DEMATEL (FDEMATEL), and the factors will be layered using ISM method. The new architecture is put forward from the aspect of theory in order to provide theory and method support for the Chinese enterprises eco-innovation.

2.5 Proposed Measures

As one of the functions of enterprise, ensuring environmental quality of products is an important way to measure the environmental performance of an enterprise (Handfield et al., 2002). Handfield et al. (2005) also pointed out that the enterprise should control reduce the Product's influence on the natural environment in the whole process from supplier to consumer. Each of these actions potentially reduce environmental impacts of the corporate's final product (Darnall et al., 2008). Hence, product (A1) is an essential capability to reflect the enterprise eco-innovation ability (Ekins, 2010; Triguero et al., 2013; Cheng et al., 2014). In order to assess enterprises eco-innovation behavior from the aspects of product, some studies have proposed possessing integral approach of green production (C1), generating value-adding in farm level (C2), maintaining the flexible and adaptive to ecologies and places(C3), promoting product to the community though green organization (C4), preventing harmful materials utilization(C5) (Horlings & Marsden, 2011; Wu et al., 2015), improving health and safety with green purchasing (C6), adopting recycling approach to reduce argi-waste (C7) and complying with environmental standards (C8), raising service quality by launching green organization (C9) (Lin et al., 2014; Wu et al., 2016; Wu et al., 2016).

According to the basic principles of contemporary marketing thought and philosophy, the concept of marketing has formed the basis of the policies and procedures, which emphasize the importance of using consumer and profits orientation by integrating marketing functions throughout the organization's key operating area (McKitterick, 1957). Most firms are keen to dealt with information from marketing function in order to better promote new product development decision (Gupta et al., 1985). Pitts et al. (2015) examine the adoption of marketing concept and how to implement in the banking industry. Marketing function (A2) plays an important role in eco-innovation (Scarpellini et al., 2016). Hence, previous studies have proposed exploring marketing through implementing E-commerce to enhance new market share (C10), utilizing green organization to generate the market needs (C11), expanding intensity of market competition for promoting green products (C12), concerning customer environmental requirements and preferences (C13), establishing special department responsible for marketing green products (C14), using local resources to develop agri-supply chain networks (C15), offering on-time agri-service (C16), market pull for green products (C17), practicing green purchasing concept to set up the price strategy (C18) and launching sustainable packaging (C19) (Azzone & Noci, 1998; Tseng, 2011a; Horlings & Marsden, 2011; Wu et al., 2015; Wu et al., 2016).

As noted by Gupta and Singhal (1993) "… people, not products, are an innovative company's major asset". From this follows that human resource management (HRM) is understood to be critical to corporate entrepreneurship (Hayton, 2005). Wong et al. (2013) point out that HRM has a strong role to the performance of the enterprise organization. HRM (A3) also has an important influence on enterprise innovation (Lewicka, 2013; Peters, 2014). Mishra et al. (2014) elaborate the need of green HRM initiatives as an innovative approach in public Enterprises. Florén et al. (2016) explore the relationship between HRM practices and entrepreneurial orientation. Several criteria address the HRM, namely, encouraging employee interaction in environmental practices, both formally and informally (C20), abilities to perform organizational adjustments (C21), environmental awareness of sales staffs (C22), facing on stakeholder pressure with positive attitude (C23), providing employee education and skills development (C24), stimulating employee aggressive participation (C25), accepting the proposed suggestions from employees (C26) and enhancing green activities within organization through internal competition (C27) (Azzone & Noci, 1998; Brunnermeier & Cohen, 2003; Tseng, 2011a; Wu et al., 2015; Wu et al., 2016; Wu et al., 2016).

In terms of technical development, we can know that the quality of knowledge stock and the level of technological capabilities acquired from R&D activities are important for the production and diffusion of eco-innovation in the micro and macro levels from existing evidence (Löschel, 2002; Popp et al., 2011). There another agreement that environmental policies and subsidies to R&D are the most important drivers of eco-innovation (Costantini et al., 2015). Green R&D for eco-innovation and its effect on firm performance are also been studied (Lee & Min, 2015). Therefore, in the measure of enterprise green innovation, R&D function (A4) is one of the most important aspects. Related criteria are explored in some studies. Collaborating with research institutes, agencies and universities (C28), applying environmental patent (C29),

setting up environmental R&D (C30), monitoring the pollution control and protection (C31), certifying eco-labeling (C32), applying eco-system to create added value for humans and nature (C33), adopting flexible and cleaner technology in R&D (C34), designing reverse logistics procedure (C35) and developing optimal inventory management (C36) (Tseng, 2011a; Horlings & Marsden, 2011; Wu et al., 2015; Wu et al., 2016; Wu et al., 2016).

Existing literature has show that the relationship of eco-innovative activities and financial performance is a popular topic (Semenova & Hassel, 2008; Heras-Saizarbitoria et al., 2011). Eco-innovation ability of firms is becoming more important which influence financial gains, but the industry, legislation and norms, and consumer sensitiveness are important for their scale and achievability (Jansson, 2011). Financial performance is the important factor of enterprise performance (Cheng et al., 2014). Finance function (A5) is relevant pre-conditions for the development of eco-innovativeness (Przychodzen & Przychodzen, 2015). Several operations in eco-innovation may assist a corporate to attain the financial capability from accessing to exist subsidies and fiscal incentives (C37), gathering financial support from investors (C38), enabling recognize potential revenue in green production (C39), controlling capital efficiency (C40), generating annual growth in revenue (C41), decreasing cost of revenue (C42) and increasing profit margin (C43) (Lin et al., 2014; Wu et al., 2015; Wu et al., 2016).

The proposed evaluation aspects and criteria can be se en in Table 1.

Table 1: Proposed evaluation aspects and criteria.

Aspects	Criteria
Product (A1)	Possessing integral approach of green production (C1)
	Generating value-adding in farm level (C2)
	Maintaining the flexible and adaptive to ecologies and places (C3)
	Promoting product to the community though green organization (C4)
	Preventing harmful materials utilization (C5)
	Improving health and safety with green purchasing (C6)
	Adopting recycling approach to reduce argi-waste (C7)
	Complying with environmental standards (C8)
	Raising service quality by launching green organization (C9)
Marketing (A2)	Expanding intensity of market competition for promoting green products (C10)
	Concerning customer environmental requirements and preferences (C11)
	Establishing special department responsible for marketing green products (C12)
	Using local resources to develop agri-supply chain networks (C13)
	Offering on-time agri-service (C14)
	Market pull for green products (C15)
	Practicing green purchasing concept to set up the price strategy (C16)
	Launching sustainable packaging (C17)
	Implementing E-commerce to enhance new market share (C18)
	Utilizing green organization to generate the market needs (C19)
HRM (A3)	Encouraging employee interaction in environmental practices, both formally and informally (C20)
	Abilities to perform organizational adjustments (C21)
	Environmental awareness of sales staffs (C22)
	Facing on stakeholder pressure with positive attitude (C23)
	Providing employee education and skills development (C24)
	Stimulating employee aggressive participation (C25)
	Accepting the proposed suggestions from employees (C26)
	Enhancing green activities within organization through internal competition (C27)

R&D (A4)	Collaborating with research institutes, agencies and universities (C28) Applying environmental patent (C29) Setting up environmental R&D (C30) Monitoring the pollution control and protection (C31) Certifying eco-labeling (C32) Applying eco-systemto create added value for humans and nature (C33) Adopting flexible and cleaner technology in R&D (C34) Designing reverse logistics procedure (C35) Developing optimal inventory management (C36)
Finance (A5)	Accessing to exist subsidies and fiscal incentives (C37) Gathering financial support from investors (C38) Enabling recognize potential revenue in green production (C39) Controlling capital efficiency (C40) Generating annual growth in revenue (C41) Decreasing cost of revenue (C42) Increasing profit margin (C43)

3. METHOD

This study explores eco-innovation for corporate functions under Chinese management style based on the proposed aspects and criteria (Table 1). FDEMATEL and ISM are used to improve the accuracy of decision and the reliability of the study. The proposed analytic procedures are presented.

3.1 FDEMATEL

Fuzzy DEMATEL (FDEMATEL) method which is a combination of DEMATEL and fuzzy logic is put forward. This approach enables a visual analysis through a visual diagram. Hence, the FDEMATEL is a tool to assist in solving complicated system problems in various areas (Tseng, 2011b; Wu et al., 2015). FDEMATEL helps solve the uncertainty when analyzing the causal relations among the enablers and also set up strategies which can manage solar development initiatives (Luthra et al., 2016). Assume that initially there are sets of attributes $S = \{S_i | i = 1,2,\cdots,n\}$ and pairwise inter-relations. The linguistic scale is then implemented into the evaluation assessment, as displayed in Table 2.

Table 2: Linguistic scales for corresponding TFNs.

Scales	Linguistic preferences	Corresponding triangular fuzzy numbers
1	No influence/importance	(0, 0.1, 0.3)
2	Very low influence/importance	(0.1, 0.3, 0.5)
3	Low influence/importance	(0.3, 0.5, 0.7)
4	High influence/importance	(0.5, 0.7, 0.9)
5	Very high influence/importance	(0.7, 0.9, 1.0)

Suppose that there are k respondents, and the linguistic scale must be transferred to triangular fuzzy numbers $\bar{\mu}_{xy} = (\mu_{xy}^{ak}, \mu_{xy}^{bk}, \mu_{xy}^{ck})$, which represent the degree to which attribute x affects attribute y in the kth response. The defuzzification process requires triangular fuzzy numbers to be converted into crisp values (Lin et al., 2014). This study adopted Max-Min to normalize the triangular fuzzy numbers before obtaining the completed crisp values. The Max-Min normalization process follows the equation below:

$$\tau\mu_{xy}^{ak} = (\mu_{xy}^{ak} - \min\mu_{xy}^{ak})/\Delta_{\min}^{\max}$$
$$\tau\mu_{xy}^{bk} = (\mu_{xy}^{bk} - \min\mu_{xy}^{bk})/\Delta_{\min}^{\max}$$
$$\tau\mu_{xy}^{ck} = (\mu_{xy}^{ck} - \min\mu_{xy}^{ak})/\Delta_{\min}^{\max}, \quad (1)$$

where $\Delta_{\min}^{\max} = \max\mu_{xy}^{ck} - \min\mu_{xy}^{ak}$

Identifying the left (l) and right (r) normalized value, we have the following:

$$\tau l_{xy}^{k} = \tau\mu_{xy}^{bk}/(1 + \tau\mu_{xy}^{bk} - \tau\mu_{xy}^{ak})$$
$$\tau r_{xy}^{k} = \tau\mu_{xy}^{ck}/(1 + \tau\mu_{xy}^{ck} - \tau\mu_{xy}^{bk}) \quad (2)$$

Then, gathering the total normalized crisp values (τ_{xy}^{k}):

$$\tau_{xy}^{k} = \left[\tau l_{xy}^{k} \times (1 - \tau l_{xy}^{k}) + (\tau r_{xy}^{k})^2\right]/[1 - \tau r_{xy}^{k} + \tau l_{xy}^{k}] \quad (3)$$

Attaining the crisp values:

$$\sigma_{xy}^{k} = \min\mu_{xy}^{ak} + \tau_{xy}^{k} \times \Delta_{\min}^{\max} \quad (4)$$

The final step of the transformation is to aggregate the crisp values:

$$\sigma_{xy} = \sum_{1}^{k} \tau_{xy}^{k}/k \quad (5)$$

To arrange these crisp values in a pairwise comparison

and express them as a direct relation matrix $F^{d}_{n\times n}$, the matrix can be rewritten as $F^{d} = [\sigma_{xy}]_{n\times n}$. Subsequently, the direct matrix F^{d} must be normalized into F^{n}, and the normalized matrix F^{n} can be obtained from the following equation:

$$F^{n} = \forall \times F^{d}, \quad (6)$$

where $\forall = 1/\max_{1\ll x\ll n}\sum_{y=1}^{n}\sigma_{xy}, x, y = 1,2,\cdots,n$

Once the normalized matrix F^{n} is obtained, it must be correlated with the identity matrix to obtain the total relation matrix F^{t}, as in the following computation:

$$F^{t} = F^{n} \times (M - F^{n})^{-1}, \quad (7)$$

where M is the identity matrix

Finally, the sums of the rows and columns in the total relation matrix are used to acquire the vectors D and R, respectively. The computation of vectors is obtained using the following equations:

$$F^{t} = [\sigma^{t}_{xy}]_{n\times n}, x, y = 1,2,\cdots,n$$
$$D = [\sum_{x=1}^{n}\sigma^{t}_{xy}]_{n\times 1} = [\sigma^{t}_{x}]_{n\times 1}$$
$$R = [\sum_{y=1}^{n}\sigma^{t}_{xy}]_{1\times n} = [\sigma^{t}_{y}]_{1\times n} \quad (8)$$

Thus, the causal diagram is produced. The vertical axis, (D - R), represents the role of the attribute. If (D - R) is negative, the attribute is considered to be the effect, whereas if (D - R) is positive, the attribute is considered to be the cause. (D + R) is the horizontal axis and represents the importance of the attributes.

3.2 ISM

Through modeling, the specific relation- ship and overall structure are portrayed in a diagram model. The main steps of the ISM procedure are summarized as follows:

a . List the criteria (sub-criteria) considered for the problem and define each criterion (sub-criterion) as e_i, $i = 1, 2, 3, \ldots, n$ (Lee et al., 2010).

b. After identifying the criteria (sub-criteria) in step a, establish a relation matrix that shows the relationship between the criteria (sub-criteria) (Lee et al., 2010). A relation matrix is made according to the opinion of the experts (Eswarlal et al., 2011). This can be done by asking questions such as, "Does the variable e_i influence the variable e_j?" If the answer is "yes," then $r_{ij} = 1$; otherwise, $r_{ij} = 0$. The general matrix of the relation matrix is presented below:

$$\text{MATRIX S:} \begin{array}{c} \\ e_1 \\ e_2 \\ \vdots \\ e_n \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & \cdots & e_n \end{array} \\ \begin{bmatrix} 0 & \rho_{12} & \cdots & \rho_{1n} \\ \rho_{21} & 0 & \cdots & \rho_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{n1} & \rho_{n2} & \cdots & 0 \end{bmatrix} \end{array},$$

$i = 1,2,\cdots,n; j = 1,2,\cdots n,$

where e_i is the ith element in the system, r_{ij} denotes the relationship between the ith and jth elements, and S is the relation matrix (Huang et al., 2005). After constructing the relation matrix, the reachability matrix can be calculated using Eqs. (9) and (10).

$$N = S + I \quad (9)$$

$$N^{*} = N^{k} = N^{k+1}, k > 1 \quad (10)$$

where I is the unit matrix, k denotes the powers, and N^{*} is the final reachability matrix. The reachability set is then calculated and the priority is set based on Eqs. (11) and (12) as follows:

$$A(ti) = \{tj|m'ij = 1\} \quad (11)$$
$$B(ti) = \{tj|m'ij = 1\} \quad (12)$$

Where m_{ij} denotes the value of the ith row and the jth column. Then, from Eq. (13), the levels and relationships between the elements can be determined and the structure of the elements' relationships can also be expressed using the graph (Shahbandarzadeh & Ghorbanpour, 2011).

$$B(ti) \cap A(ti) = B(ti) \quad (13)$$

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