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Using a hybrid MCDM model to evaluate firm environmental knowledge management in uncertainty

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ABSTRACT

Environmental practice in knowledge management capability (EKMC) is a complex uncertainty concept that is difficult to determine based on a firm's real situation because measuring EKMC requires a set of qualitative and quantitative measurements. A framework is proposed and uses a novel hybrid multi-criteria decision-making (MCDM) model to address the dependence relationships of criteria with the aid of the analytical network process (ANP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) in uncertainty. Fuzzy set theory is used to interpret the linguistic information in accordance with the subjective evaluation; ANP is used to analyze the dependence aspects, while DEMATEL is used to determine the intertwined relations among the criteria. The evaluation results obtained through the proposed approach are objective and unbiased for two reasons. First, the results are generated by a group of experts in the presence of motile attributes, and second, the fuzzy linguistic approach reduces the distortion and loss of information. Managers can then judge the need to improve and determine which criteria provide the most effective direction towards improvement.

1. Introduction

Facing a globally competitive and fluctuating environment, organizations require continual managing of their resources to maintain competitive advantages. The possible role of knowledge management (KM) has been described in creating sustained competitive advantages for organizations [1,2]. Clark et al. [3], however, pointed out that KM integration is dependent on a wider and trans-functional integration capability. Lubit [4] reported that tacit knowledge and superior knowledge management capabilities (KMC) are the keys to a sustainable competitive advantage in various industries; a similar result that KMC has a tremendous effect on competitiveness has been reported by Liu et al. [50]. Today, environmental practices are also an overall strategic organizational approach to planning product/process design, top management support, production practices, organizational design and effects on the manufacturing performance [5,6]. However, the environmental practices are dependent on wider knowledge integration to achieve a firm's goal of waste elimination due to mandated environmental orders from the European Union, such as the Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (ROHS) Directives. Hence, firms must integrate environmental practices and KMC to ensure corporate survival and sustainable development. Environmental practice in KMC (EKMC) is an important activity that helps firms make continuous environmental improvements by placing great emphasis on green product development coming into the competitive and sustainable market. EKMC engenders multi-dimensional difficulties that involve numerous organizational functions and resource integration among various departments [5,6]. However, the evaluation-related activities have inherent and high uncertainty and imprecision, and it is difficult to assess accurately with both qualitative and quantitative measurements.

Hence, judgment in social science measurements is always represented by exact numbers; it is generally understood that human perceptions of decision criteria are judged subjectively. In many practical cases, the human preference model is uncertain and might be reluctant or unable to assign exact numerical values to describe preferences [5–7]. Since some of the evaluation criteria are subjective and qualitative in nature and are described using linguistic information, it is very difficult for the decision maker to express preferences using exact numerical values, making it more desirable for the researchers to use a fuzzy logic evaluation. The algorithm developed by Opricovic and Tzeng [8] effectively aggregates the assessment of the decision makers to each criterion by using an overall fuzzy number, and defuzzification captures the importance of the criteria based on the opinion of the decision makers. Unfortunately, few studies have measured linguistic preferences in EKMC.

A challenge of this study is that EKMC evaluation is always uncertain because marketing information is rapidly changing, and

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infrastructure capability, process capability, R&D capability and innovation decision capability are measured qualitatively and quantitatively. Organization scientists have traditionally defined uncertainty as a lack of information or knowledge. This study suggests that EKMC is complex and composed of interaction processes of many different resources; therefore, multi-dimensional and corresponding indicators reflect the EKMC. Hence, a traditional multi-criteria approach is not suited to evaluate the firms that the nature of criteria are composed of complex relations. To indicate the EKMC interdependence aspects and intertwined criteria, for instance, a firm that has outstanding R&D capability to perform advanced research and create unique designs often possesses good process capabilities such as acquisition-oriented KM processes, as well as those oriented toward obtaining knowledge. Such R&D capability is also related to innovation decision capability, which is required for KM innovation and for reducing uncertainty and risk activities. The ANP and DEMATEL are the most suitable tools for this study, where the goal is to understand the hierarchical intertwined relations as well as the cause and effect.

DEMATEL is a mathematical computational method that can convert the relations between the cause and effect of criteria into a visual structural model [9,10]. In addition, it can be used as an effective method to handle the inner dependences within a set of criteria. The main advantage of DEMATEL is that it involves indirect relations within a cause and effect model. The DEMATEL method is an effective procedure for analyzing structure and relationships between components; it can prioritize the criteria based on the type of relationships and severity of influences they have on one another. The criteria having a greater effect on one another are assumed to have a higher priority and are called cause criteria. In contrast, those that receive more influence from another are assumed to have lower priority and are called effect criteria [11]. The advantage of using a combination of fuzzy set theory, ANP and DEMATEL is that it considers the hierarchical structure, including interdependence relationships in the condition of fuzziness, and flexibly manages the fuzziness situation. With these advantages, the DEMATEL method is used to determine the cause and effect of criteria and to understand the hierarchical structure with interdependence relations; ANP is proposed for application in a hierarchical structure.

Hence, using the fuzzy measurements, ANP and DEMATEL, subjectivity, uncertainty and interactivity can be combined with triangular fuzzy numbers (TFNs) to eliminate expert subjective judgment problems involving complex hierarchical relationships among EKMC aspects and criteria. This study provides an analytical approach for managerial decision making. It demonstrates that the quantitative technique of interdependences among various aspects and criteria can be effectively captured using the ANP technique and combined with DEMATEL, which is rarely applied in the literature. This study attempts to develop a hierarchical framework that is sufficiently general that it can be applied under various research settings. To date, few studies have adopted a rigorous methodology; this study presents a hierarchical analytical approach that is sufficiently general. The unique point of this study is that it takes qualitative and quantitative measures in linguistic terms presented by TFNs and defuzzifies them into a crisp value for analysis using a cause and effect model. Resolving problems in evaluating a firm is fundamentally important to both researchers and practitioners. The remainder of this paper is organized as follows. Section 2 clarifies the background of the EKMC and discusses the relevant literature. Section 3 presents the structure of the framework of this study. Section 4 presents the proposed methods of fuzzy set theory, ANP and DEMATEL. Section 5 subsequently applies a proposed method in evaluating a firm. This is followed by a discussion and managerial implications in Section 6. Finally, conclusions are drawn in Section 7.

2. Background of firm EKMC

To successfully manage the challenges of globalization and intensive competition in sustainable development, firms need to be aware of environmental practices in KMC. KM is the explicit and systematic management of vital knowledge and its associated processes of creation, organization, diffusion, use and exploitation. Clark et al. [3] reported that KM integration is dependent on a wider and trans-functional integration capabilities. KM capabilities included knowledge capture, documentation, and sharing within a project team or organization. It has increasingly become a business process, supported by database technologies and activities aimed at the creation and sharing of knowledge [12]. Appropriate KM strategies are important to ensure that the alignment of the organizational process, culture, and the related information technology (IT) deployment produce effective knowledge creation, sharing, and utilization [13]. Tsai [14] defined KM as knowledge obtaining, knowledge refining, knowledge storing and knowledge sharing. Lin [15] noted that product life cycles are currently becoming shorter and emphasized that the way for an enterprise to win this battle is to cultivate core capabilities and convert them into a sharp weapon. The capture of knowledge, the exploitation of existing knowledge, and the distribution of new knowledge are critical for long-term sustainable development.

Moreover, KM is a large, interdisciplinary field. Many manufacturers have embraced the concept of environmental consciousness to improve their product development, quality goals, and to eliminate waste. KM has enabled firms to exploit their strengths and technologies to support environmental issues [16–19]. Moorman [20] reported that a firm's capability to absorb market information would reduce market uncertainty and enable it to obtain comparatively high successful opportunities. Davenport et al. [49] concluded from a case study that a successful KM system for an enterprise must contain a skill resource knowledge bank. KM has become one of the necessary conditions for enterprises to survive in a competitive environment. Veryzer [21] used two important aspects: technological capability and product capability. Technological capability means that a product must be made using a technology beyond the current company technological level, and product capability represents the benefit of a product recognized or experienced by customers. Desouza [22] argued that an ideal organization with well-matured KMC can ensure the identification, distribution, protection, application and destruction of knowledge that is the key to preventing an organizational crisis. However, no work has dealt with the combination of environmental practices and KMC.

Mostly, the relevant issues of environmental practices and knowledge management are described in ontology studies. For instance, Kitamura and Riichiro [23] proposed the use of ontology together with functional decomposition trees and described the ontology as two levels. The first level, the behavioral level, consists of device connections between devices, assembly relations of devices and behaviors of entities. The behavior means the interpretation of its input–output relations when considering it as a black box. The second level, the functional level, represents the description of the final causes of a system related to the designer's intent. In the field of environmental decision support, Ceccaroni et al. [24] developed a knowledge-based system dedicated to diagnosing failures in a waste water treatment plant that is supported by ontology specialized in the waste water domain. The domain takes into account the evolution of microorganism communities, which are considered a key element in the biological treatment process. In an ontological analysis of relevant process information presented by Morbach et al. [25], the approach was ontology used in the domain of chemical and computer-aided process engineering; it included design, construction and operations. The aim of their