Knowledge Management Adoption and Assessment for SMEs by fuzzy Decision Making Techniques

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Abstract

This paper proposes a Fuzzy Group Decision Approach for making strategic decisions about knowledge management adoption.

Most SMEs are suffering because of low profits caused by hyper competition and OEM dead-end. Moreover, since the middle of 2008, the financial tsunami has caused serious damage to the global economy. They lack the financial and systematic basis to introduce knowledge management practices and make innovations. Several researchers have explored the gaps in the knowledge management activities of enterprises. Their studies reveal that corporate performance is significantly influenced by those gaps.

Our research aimed to clarify the misunderstanding of high expenditure on knowledge management systems adoption, and provided a novel approach for the most emergent knowledge management components to catch up the paces of their rival for the late adopter of knowledge management systems.

The DEMATEL (Decision MAking Trial and Evaluation Laboratory) method gathers collective knowledge to capture the causal relationships between strategic criteria. This paper applies the DEMATEL method in the strategic planning of knowledge management to help managers address the above situations and related questions.

Keywords: Fuzzy Decision Making, Knowledge Management, Small and Medium Enterprises, MCDM

1. Introduction

Knowledge management (KM) has emerged as a major issue that managers must deal with if they want to maintain and strengthen their organization’s competitive advantage. However, practitioners are often confused about how to start the roadmap of the KM journey, which KM strategy they should adopt, and what they should do next. To help answer these and related questions, we believe a fuzzy group decision approach is suitable.

Managers usually make strategic decisions based on a single purpose or dimension, but strategic planning is influenced by many different factors and viewed from several perspectives, such as cultural, technological and structural standpoints. Since the traditional concept of strategic planning lacks a multi-dimensional emphasis, in this paper, we use the DEMATEL method to construct the relationships between decision factors for KM strategic planning. The relationships support a multi-level approach to planning strategy.

2. Literature Review

2.1 Knowledge Management Capabilities

From the resource-based view, while resources serve as the basic units of analyses, firms create competitive advantage by assembling resources that work together to create organizational capabilities (Bharadwaj 2000). Such capabilities refer to an organization’s ability to assemble, integrate, and deploy valued resources, usually, in combination or co-presence (Amit and Schoemaker 1993; Russo and Fouts 1997; Schendel 1994; Bharadwaj 2000). Therefore, an organizational knowledge management capability is defined as its ability to create, transfer, integrate, and leverage related knowledge across its business units (Tanriverdi 2005).

Gold et al. (2001) examined the issue of effective knowledge management from the perspective of organizational capabilities. It is suggested that, in a knowledge infrastructure, technology, structure, and culture as well as a knowledge process architecture of acquisition, conversion, application, and protection are essential organizational capabilities for effective knowledge management.

Hung et al (2005) proposed a three dimensional Knowledge Management Pyramid Model (KMPM), which
is comprised of three components, namely, maturity levels, knowledge management processes, and knowledge management capabilities or enabling infrastructures. The concept of maturity levels is based on the staged representation of Capability Maturity Model Integration (CMMI) of SEI and follows Ehms’ (2002) five levels of maturity, i.e., initial, repeated, defined, managed, and optimizing.

The model divides the knowledge management process into four sub-processes: knowledge creation, knowledge storage, knowledge sharing, and knowledge application, thus emphasizing the need for continuous process improvement. From the capability perspective, the structural infrastructure refers to the presence of norms and trust mechanisms. The cultural dimension is built upon a sharing context, and the technological dimension addresses the technology-enabled infrastructures that exist within the firm. These three knowledge management enablers play a critical role in supporting knowledge management activities at each maturity level.

2.3 Knowledge Management Capability Components

We referenced several important papers in KM and selected forty significant components of KM capability, which were then screened and filtered by six experts in the knowledge management field, including academics and practitioners. The components of KM Capability are the four knowledge management sub-processes listed above, which are supported by three knowledge infrastructure capabilities, i.e., cultural infrastructure, technological infrastructure, and structural infrastructure.

2.4 OKMR (Organizational Knowledge Management Readiness)

Several IS related researches focused on organizational readiness, such as, Parasuraman (2000) developed the TRI index (Technology Readiness Index) and refined a multiple-item scale as a means of measuring the readiness to embrace new technologies, and also assessed the scale’s psychometric properties. Moreover, several theoretical propositions and research, such as Net-Enabled Business Innovation Cycle (NEBIC), highlighted the interplay between strategy, IS and entrepreneurship in a quest for competitive advantage (Zahra and George 2002; Wheeler 2002).

Therefore, while Organizational theorists and strategists studied the construct of technology readiness of people, KM researchers studied organizational readiness of knowledge management for assessing the effectiveness. Taylor et al (2004) studied the Organizational readiness for successful knowledge sharing and investigated knowledge sharing in one public service context. Siemieniuch et al (2004) proposed a framework for organizational readiness for knowledge management by the introduction of knowledge lifecycle management (KLM) processes.

The critical issue is that the performance of the IS function is now under the microscope and decisions to insource/outsourse and spend/not spend must be made in a structured context (Chang and King 2005). Therefore, the objective of this phase is to develop such an instrument— for evaluating overall knowledge management context. That is to construct an instrument for measuring organizational knowledge management Readiness as a means to help answer these and related questions.

3. Research Method

3.1 OKMR instrument development

Churchill (1979) recommended specifying the domain of the construct followed by generating a sample of items as the first two steps in instrument development to ensure content validity. Domain development should be based on existing theories, and sample items should come from existing instruments, with the development of new items when necessary. Therefore, Three KM-related focus group interviews with Three professors, five doctoral students and nine practitioners were taken to modify, eliminate, and refine those items.

The Delphi method was used to reach the most reliable consensus for the instrument development pool. Then, a 30-item list that constituted a complete domain for OKMR (Organizational Knowledge Management Readiness) measurement was obtained. Pre-testing and pilot testing of the measures were conducted by selected users from the KM field, as well as experts in the area. Only two ambiguous items were modified in this stage.
3.2 The DEMATEL Method

Because evaluation of knowledge management capabilities cannot accurately estimate each considered criterion in terms of numerical values for the alternatives, fuzziness is an appropriate approach. The DEMATEL method is an emerging method that gathers group knowledge to capture the causal relationships between criteria.

The original DEMATEL (DEcision-MAking Trial and Evaluation Laboratory) method studied the disjointed and antagonistic phenomena of world and investigated integrated solutions. In 1973, the Battelle Memorial Institute conducted the DEMATEL project through its Geneva Research Centre. In recent years, this method has become very popular in Japan.

It is especially practical and useful for visualizing the structure of complicated causal relationships with matrices or digraphs, which portray the contextual relations between the elements of a system, where a numeral represents the strength of influence. Therefore, the DEMATEL method can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system.

The DEMATEL method has been successfully applied in many fields. For example, Tamura et al. (2002) try to decrease anxiety of people by extracting and analyzing various uneasy factors in order to create future safe, secure and reliable (SSR) society. More recently, Chiu et al. (2005) adopted the method to study marketing strategy based on customer behavior related to LCD-TVs. Also Hori and Shimizu (1999) employed it to design and evaluate the software of a display-screen structure for analyzing a supervisory control system.

The digraph portrays a contextual relationship between the elements of the system, in which a numeral represents the strength of influence (Fig. 2). The elements c, d, e, f and g represent the factors that have relationships in Fig. 2. The number between factors is influence or influenced degree.

For example, an arrow from s1 to s2 represents the fact that s1 influences s2 and its influenced degree is two. The DEMATEL method can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system (Chiu et al., 2006).

3.2.1 The Fuzzy Number and Linguistic Variables

Since fuzzy set theory was initially proposed by Zadeh, and Bellman and Zadeh (1970) subsequently described the decision-making methods in fuzzy environments, an increasing number of studies have dealt with uncertain fuzzy problems by applying fuzzy set theory. Similarly, this study adopts fuzzy decision-making theory by
considering possible fuzzy subjective judgments during the evaluation process of strategic planning for KM implementation.

It is very difficult for traditional quantification methods to reasonably express situations that are overtly complex or hard to define; therefore, the notion of linguistic variables is a useful tool in such situations. The theory of linguistic variables is used to represent the imprecision of spatial data and human cognition in terms of the criteria used for the evaluation process. A linguistic variable is a variable whose values are words or sentences in a natural or artificial language. We use this approach to evaluate criteria represented by linguistic variables in a fuzzy environment as “Very high influence”, “High influence”, “Low influence”, and “No influence” on a four-level fuzzy scale.

The use of linguistic variables is widespread and, in this study, the linguistic values of alternatives are primarily used to assess the linguistic ratings given by decision-makers. Furthermore, linguistic variables are used to measure the performance value of alternatives for each criterion as “no influence”, “low influence”, “high influence”, and “very high influence”. We use triangular fuzzy numbers to express the fuzzy scale, as shown in Step 1 of the evaluation process.

3.2.2 The Fuzzy DEMATEL Method Procedure

A unique characteristic of this method is that it shows the relationships between KM capability components with certain scores by using matrix operations. The relationship is that of “cause and effect”. Another important characteristic is that it grasps both the direct effects, and the indirect effects of competing components.

We use triangular fuzzy numbers (TFN) with fuzzy DEMATEL to establish fuzzy weights for the 40 knowledge management capability components and to determine the relative importance of the criteria. Then, the performance value of each criterion can be derived by the decision-makers. After the synthetic utility values are derived, we rank the alternatives based on the best non-fuzzy performances (BNP). The procedures of the DEMATEL method and the evaluation methods can be summarized as follows:

Step 1: Producing the direct-relation matrix

<table>
<thead>
<tr>
<th>Numeral</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No influence</td>
</tr>
<tr>
<td>1</td>
<td>Low influence</td>
</tr>
</tbody>
</table>

Comparison scale of the DEMATEL method

Step 2: Normalizing the direct-relation matrix

On the basis of the direct-relation matrix $A$, the normalized direct-relation matrix $X$ can be obtained through formulas (1) and (2):

$$X = k \cdot A$$

$$k = \frac{1}{\max \sum_{j=1}^{n} a_{ij}}, \quad i, j = 1, \ldots, n.$$  

Step 3: obtaining the total-relation matrix

Once the normalized direct-relation matrix $X$ has been obtained, the total-relation matrix $T$ can be derived by using formula (3), in which the $I$ denotes the identity matrix.

$$T = X + X^2 + X^3 + \ldots = X(I + X + X^2 + \ldots)$$

$$T = X(I - X)^{-1}, \quad \text{when } n \to \infty, \quad X^n = 0$$

Step 4: Analyzing the results

In this step, the sum of rows and the sum of columns are used to derive vector $s$ and vector $r$ respectively, as shown in formulas (4), (5), and (6). Then, the horizontal axis vector $(s + r)$, called “Prominence”, is formed by adding $s$ to $r$, which indicates the level of importance of the criterion. Similarly, the vertical axis $(s - r)$ called “Relation”, is formed by subtracting $s$ from $r$, which may divide criteria into a cause group and an effect group. When $(s - r)$ is positive, the criterion belongs to the cause group; otherwise, it belongs to the effect group. Therefore, the causal diagram can be derived by mapping the dataset of $(s + r, s - r)$, which provides valuable insights for making decisions.

$$T = [t_{ij}]_{n \times n}, \quad i, j = 1, \ldots, n$$  

Step 3\textsuperscript{2}
\[ s = \left[ \sum_{j=1}^{n} t_{ij} \right]_{no \times d} = [t_i]_{no \times d} \]

(5)

\[ r = \left[ \sum_{i=1}^{n} t_{ij} \right]_{no \times o} = [t_j]_{no \times o} \]

(6)

where vector \( s \) and vector \( r \) respectively denote the sum of rows and the sum of columns from the total-relation matrix \( T = [t_{ij}]_{no \times o} \).

3.3 Result

Table 2 Organizations’ priorities of four KM sub-processes, and causal relationships between criteria.

<table>
<thead>
<tr>
<th>Knowledge creation</th>
<th>Knowledge storage</th>
<th>Knowledge sharing</th>
<th>Knowledge application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.62</td>
<td>1.96</td>
<td>1.46</td>
<td>1.77</td>
</tr>
<tr>
<td>1.79</td>
<td>1.56</td>
<td>1.42</td>
<td>1.64</td>
</tr>
<tr>
<td>1.24</td>
<td>1.28</td>
<td>0.86</td>
<td>1.19</td>
</tr>
<tr>
<td>1.64</td>
<td>1.63</td>
<td>1.25</td>
<td>1.29</td>
</tr>
</tbody>
</table>

Figure 3. Knowledge Creation has strongest causes and effects in case A of our study.

4. Conclusion and Findings

We have proposed an approach for the strategic planning of knowledge management based on effective group decision-making from the perspective of knowledge management processes. The fuzzy DEMATEL method is used to establish fuzzy weights for forty knowledge management capability components.

A 27-item list that constituted a complete domain for OKMR (Organizational Knowledge Management Readiness) measurement was obtained, which are used to construct the criteria of knowledge management adoption.

The contribution of our approach is that it overcomes the limitations of traditional methods used to evaluate the implementation of knowledge management capabilities, as it does not have to accurately estimate the considered criteria in terms of numerical values for the anticipated alternatives. Applying fuzziness and the DEMATEL method to the strategic planning of knowledge management allows practitioners to select components according to their organizations’ priorities, and gather meaningful knowledge that captures the causal relationships between criteria.

5. References


Table 3  The operation of a relation matrix of four KM sub-processes by applying Fuzzy DEMATEL

<table>
<thead>
<tr>
<th>KM process</th>
<th>Value</th>
<th>KM process</th>
<th>Value</th>
<th>KM process</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.S.</td>
<td>6.41</td>
<td>K.S.</td>
<td>6.29</td>
<td>K.S.</td>
<td>12.8</td>
</tr>
<tr>
<td>K.SH.</td>
<td>5.81</td>
<td>K.SH.</td>
<td>5.89</td>
<td>K.SH.</td>
<td>11.7</td>
</tr>
</tbody>
</table>

K.C.: knowledge creation  K.S.: knowledge storage
K.SH.: knowledge sharing  K.A.: knowledge application