Applying fuzzy quality function deployment to prioritize solutions of knowledge management for an international port in Taiwan

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ABSTRACT

The purpose of this paper is to apply a fuzzy quality function deployment (QFD) approach to prioritize knowledge management (KM) solutions for an international port in Taiwan. First, the paper examines house of quality (HOQ) matrices to facilitate handling of the 'what' (i.e., KM requirements) and 'how' (KM solutions) aspects of the QFD problem, and proposes procedures for the use of a fuzzy QFD method. A case study concerning port K in Taiwan is then used to demonstrate a systematic appraisal process for prioritizing KM solutions, and twenty attributes with sixteen feasible KM implementation solutions are measured employing an HOQ matrix. Finally, the top five feasible solutions for implementing KM at port K are identified. The empirical results show that 'establishment of a data storage and data mining system' in the technology dimension is the most urgent requirement for KM implementation at port K in Taiwan.

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1. Introduction

Traditionally, labor, land, capital, and an entrepreneurial spirit are seen by businesses and organizations as the most fundamental factors of production. In an age of exploding information, however, an enterprise needs to integrate its knowledge and transform it into useful resources that can help it maintain or create a competitive edge. In his *Post-Capitalist Society*, management guru Drucker [18] pointed out that in today's society, the key factor of production providing real dominance is not capital, land, or labor, but rather knowledge, highlighting the reality that knowledge has become an important production element.

Knowledge is an unlimited resource and asset [39] that can grow as it is used, and organizations can continue to innovate and progress through internal and external competition and friction. Both in the present and the future, knowledge will remain an important tool by which enterprises can boost their competitiveness. The key to the success of an enterprise lies in the continued application and accumulation of knowledge, and the steady growth of knowledge through continuous learning and innovation.

Knowledge management (KM) [2] involves the conversion of data into useful information which can be applied as knowledge. It is a process in which data and information are processed and analyzed to become valuable knowledge, which can help businesses and organizations make profits, reduce costs, boost competitiveness, and generate both tangible and intangible assets

[2,21,48]. Zack [48] suggests that knowledge is a strategic resource that is difficult to copy or acquire, and the time needed to obtain knowledge cannot necessarily be shortened by increased investment. As a result, knowledge can offer both synergetic effects and increasing returns. Thus, the acquisition, integration, storage, and sharing of knowledge are the basis for an enterprise's creation and maintenance of a competitive edge [27,31].

Nonaka and Takeuchi [33] and Polanyi [37] contend that tacit knowledge is a subjective concept that requires personal experience and can only be accumulated over time, and is also a form of knowledge that cannot be transferred through language and can only be shared via either interpersonal interactions or personal experience. Due to its higher production cost and lower chance of repeated use, tacit knowledge is normally applied by businesses to higher added value production activities. In contrast, since explicit knowledge can be transmitted to others via other media, it can be spread in a more effective and faster manner, leading people to believe that explicit knowledge is the most important factor of production in a knowledge-based economy. Because explicit knowledge has a wider range of application and can be repeatedly used, duplicated and learned, it can be passed on and spread through tabulation, generalization, classification and storage.

The Organization for Economic Cooperation and Development (OECD) [36] argues that a knowledge-based economic framework will bring about changes in the pattern of global economic development. In a knowledge economy age, the creation of enterprise value hinges on technology, entrepreneurial spirit, and innovation. With the development and advance of various technologies, a new economic era has now arrived. To enhance competitiveness,

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improve efficiency, and lower operating costs, organizations should treat their knowledge as an asset and manage it accordingly, share and transfer correct know-how, and transform themselves into knowledge-oriented organizations.

KM involves the use of a series of knowledge creation, acquisition, and application processes for the improvement of organizational performance. Hence, the success of an enterprise requires both innovation and application of knowledge to gain competitive advantages and promote KM [4]. A growing range of organizations are thus focusing attention on KM. In short, knowledge management treats knowledge as an asset and manages it in a systematic way to achieve the goal of enhancement of organizational performance and competitiveness.

In recent years, a growing body of literature [2,4,8,10–12,20,21,26–28,31,40,41,45,46,48] has addressed the subject of KM, which underscores the widespread attention this topic has received. However, a review of relevant literature suggests that the application of KM is still limited to manufacturing, high-tech industry, knowledge-intensive industry, service industries having frequent interactions with customers, and some government agencies. Despite the fact that there have been studies on the application of KM to the maritime transport industry [47], discussion of its application to port management remains scanty.

The integration of port service functions and their connection with the country's industrial development not only result in beneficial economic clustering effects but also boost the market effectiveness of the production sector. Moreover, the development of global trade has further changed the management of traditional maritime transport and led to critical changes in the international maritime transport service market system. Haynes et al. [24] suggested that factors connected with the success of a fourth-generation port operation [44] include technology, human resources, resource integration strategies, and application of knowledge. With the development of KM and the knowledge-based economy, these competitive port knowledge service capabilities have expanded to play a functional role, which further demonstrates the important role played by KM in modern seaport operations.

Ports are a type of service industry [3], but there are discrepancies in perceived importance and satisfaction when KM is implemented by port operators. In order to enhance KM implementation performance, successful, concrete, feasibility solutions must be proposed in order to resolve the issue of these discrepancies. The quality function deployment (QFD) method offers just such a solution. There are situations in which information is incomplete or imprecise, or when views subjective or endowed with linguistic characteristics [50], creating a 'fuzzy' [49] decision-making environment. The fuzziness-based quality function deployment (fuzzy QFD) approach can be used to evaluate the relationships between the requirements and solutions of implementing KM for port operators. By using the fuzzy QFD approach, KM implementation requirements can be transformed into technical requirements able to improve KM performance.

In summary, the purpose of this paper is to apply the fuzzy QFD method to prioritize technical KM solutions for an international port in Taiwan. The first section provides background information. The following section presents the research methodology, while the third section describes the fuzzy QFD procedures. The fourth section consists of an empirical case study, and the final section offers our conclusions.

2. Research methodology

In this section, some of the concepts and methods used in this paper are briefly introduced. These include the triangular fuzzy numbers and the algebraic operations, linguistic values, and the ranking of fuzzy numbers, respectively.

2.1. Triangular fuzzy numbers and the algebraic operations

In a universe of discourse X, a fuzzy subset A of X is defined by a membership function $f_A(x)$, which maps each element x in X to a real number in the interval $[0,1]$. The function value $f_A(x)$ represents the grade of membership of x in A.

A fuzzy number A [19] in real line is a triangular fuzzy number if its membership function $f_A : \Re \to [0,1]$ is

$$f_A(x) = \begin{cases} (x-c)/(a-c), & c \leqslant x \leqslant a \\ (x-b)/(a-b), & a \leqslant x \leqslant b \\ 0, & otherwise \end{cases} \quad (1)$$

with $-\infty < c \leqslant a \leqslant b < \infty$. The triangular fuzzy number can be denoted by (c,a,b). The parameter a gives the maximum grade of $f_A(x)$, i.e., $f_A(a) = 1$; it is the most probable value of the evaluation data. In addition, 'c' and 'b' are the lower and upper bounds of the available area for the evaluation data. They are used to reflect the fuzziness of the evaluation data. The narrower the interval $[c,b]$, the lower is the degree of fuzziness of the evaluation data.

Let $A_1 = (c_1, a_1, b_1)$ and $A_2 = (c_2, a_2, b_2)$ be fuzzy numbers. According to the extension principle [49], the algebraic operations of any two fuzzy numbers A_1 and A_2 can be expressed as

• Fuzzy addition, $\oplus$:

$$A_1 \oplus A_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2);$$

• Fuzzy multiplication, $\otimes$:
$$k \otimes A_2 = (kc_2, ka_2, kb_2), \quad k \in \Re, \quad k \geqslant 0;$$

$$A_1 \otimes A_2 \cong (c_1 c_2, a_1 a_2, b_1 b_2), \quad c_1 \geqslant 0, c_2 \geqslant 0.$$

2.2. Linguistic values

In this paper, linguistic values [29,50] characterized by triangular fuzzy numbers are employed to express the fuzzy relationship degree between the KM requirements and solutions. According to the practical needs and for matching the fuzzy QFD approach developed in this paper, the fuzzy relationship degree set is defined as $S = \{High, Medium, Low, Non\}$. The linguistic values can be defined as $High = (0.5, 0.75, 1)$, $Medium = (0.25, 0.5, 0.75)$, $Low = (0, 0.25, 0.5)$, and $Non = (0,0,0)$, respectively.

2.3. Ranking of fuzzy numbers

In a fuzzy decision-making environment, ranking the alternatives under consideration is essential. To match the fuzzy QFD approach developed in this paper, and to solve the problem powerfully, the graded mean integration representation (GMIR) method, proposed by Chen and Hsieh [7] in 2000, is employed to determine the priority order of execution to all technical solutions.

Let $A_i = (c_i, a_i, b_i)$, $i = 1, 2, \ldots, n$, be n triangular fuzzy numbers. By the GMIR method, the GMIR value $P(A_i)$ of A_i is

$$P(A_i) = (c_i + 4a_i + b_i)/6 \quad (2)$$

Suppose $P(A_i)$ and $P(A_j)$ are the GMIR values of the triangular fuzzy numbers A_i and A_j, respectively. We define:
• $A_i > A_j \leftrightarrow P(A_i) > P(A_j)$,
• $A_i < A_j \Longleftrightarrow P(A_i) < P(A_j)$,
• $A_i = A_j \Longleftrightarrow P(A_i) = P(A_j)$.