An Alternative to Coping with COVID-19—Knowledge Management Applied to the Banking Industry in Taiwan

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Abstract: This study seeks to find an alternative strategy to cope with the impact of COVID-19. Though various measures have been adopted to respond to the threat of the pandemic, the problem remains unchanged. Undoubtedly, COVID-19 is also a crisis of knowledge, so this study explores whether the banking industry in Taiwan can apply knowledge management (KM) and fight the catastrophe of the century successfully and effectively. This study adopts an actual case to analyze the relationship between KM implementation and the banking industry; applies consistent fuzzy preference relations (CFPRs) to evaluate influential criteria including computational simplicity and guarantee the consistency of decision matrices; illustrates a decision-making model with seven criteria; and conducts pairwise comparisons, which are utilized to determine the priority weights of influential criteria amongst the outcome rankings and to formulate accurate KM strategies. The results show that predictions of success probabilities are higher than those of failure probabilities among the seven influential criteria and, in particular, the headquarters system and human resources are the most important priority indicators for implementing KM successfully during the pandemic or post-pandemic. The conclusion suggests significant policy implications for policymakers within other industries or countries in coping with COVID-19.

Keywords: COVID-19; knowledge management (KM); banking industry; fuzzy preference relations (CFPRs); post-pandemic

1. Introduction

COVID-19 has damaged the international economy and banking systems worldwide. Hence, banks' performance and profitability were influenced significantly (Gazi et al. 2022b). The results indicated that the volatility spillover index increased during the pandemic crisis (Mohamed and Eddin 2022). In other words, the banks were the main sector associated with volatility spillover (Chirilă 2022). Therefore, commercial banks were also exposed to the pandemic, which had a negative impact on their efficiency and productivity (Ünlü et al. 2022). Accordingly, it was found that insured or uninsured depositors chose different banks due to the pandemic as a result of the effect of political and financial events (Ghouse et al. 2022).

Facing the impact and challenges derived from the pandemic, some responsive measures needed to be adopted by the banking industry. Digitalization was the measure mentioned most often. Stefanovic et al. (2021) proposed that digitalization was an important factor and needed to be strengthened and included in bank strategies during the pandemic. Szili et al. (2022) argued that many factors could affect the choice made by banks because these factors might also change and speed up the digitalization of banks. Supari and Anton (2022) highlighted that it was necessary to intervene in small and medium enterprises and help them to increase their resilience by means of digitalization. Specifically, the

financial digitalization technologies that were usually employed by the banking industry to respond to the pandemic included Fintech (Abdul-Rahim et al. 2022), online payment, a hybrid machine learning and swarm metaheuristic approach (Jovanovic et al. 2022), and big data from FinTech websites (Sakas et al. 2022). Similarly, Ar and Abbas (2021a) explored the application of information communication technology in the Pakistani government and also recognized the contributions to COVID-19, ICT, the e-government, and public–private collaboration.

In addition, the corporate governance mechanism was thought to be effective in improving the financial performance of banks during the pandemic (El-Chaarani et al. 2022). Therefore, corporate governance had been regarded as the moderator of knowledge management, business strategy, and innovation capabilities, which are important to improving organizational effectiveness and competitiveness (Kien and That 2022). Furthermore, Kabbani et al. (2022) suggested that banks should encourage leaders to strengthen suitable behaviors and attitudes to create an ethical culture and improve employees' willingness to get the COVID-19 vaccination. Additionally, Soemitra and Rahma (2022) proposed that the Micro Waqf Bank had played a role in empowering women to deal with the COVID-19 pandemic.

However, few studies have addressed knowledge management applied to the banking industry to help cope with the pandemic, even though it was proven that the hospitality industry succeeded in implementing knowledge management post-pandemic (Hsieh et al. 2020). Due to several issues that have undoubtedly remained unsolved in the banking industry, the importance of knowledge management has quickly regained attention. Therefore, the purpose of this study was to first determine the influential criteria of implementing knowledge management effectively and to predict the probability of the successful implementation of knowledge management in the banking industry. Accordingly, this study reviewed the current literature, documents, and associated articles, along with experts and scholars specialized in the academic field of the banking. An actual case study was employed to interview 15 experts in Taiwan. Seven criteria were investigated, and the related primary data were summarized into two categories. One was to address the secondary data, whereas the other was to address the primary data collected from 18 to 24 March 2021 through the surveys and interviews of the experts.

Based on the results of the interviews, this study employed consistent fuzzy preference relations (CFPRs) to describe an analytic hierarchical prediction model, aiming at helping the banking industry in Taiwan to overcome the pandemic. Then, to rate the best implementation of knowledge management, this study employed pairwise comparisons to calculate and rank the priority weights of the seven criteria, and two outcomes (success or failure) were presented. It was expected that the model could help the banking industry to identify which criteria were vital to implement knowledge management effectively and successfully in the post-pandemic era.

2. The Review of the Professional and Academic Literature

Initially, the pandemic was a health emergency and eventually caused an unpredictably negative influence on the global economy. Unfortunately, no country could be regarded as exemplary in their response to the economic crisis caused by the pandemic (Mustafa et al. 2021). Amir et al. (2021) also asserted that education, communication, and information were the primary methods in the early phase of the pandemic before the vaccines. Akram et al. (2018) argued that the banking industry had to continue to review its explicit and implicit management strategies to meet changing consumer needs and its sustainable development to improve organizational performance because the impact on the banking industry, especially consumer finance, was immediately apparent. Mila et al. (2021) stressed that knowledge management played a vital role during the COVID-19 outbreak, although knowledge management strategies were different in domestic and foreign enterprises and had different impacts on the varying levels of organizations. Therefore, supported by successful sustainability performance and a competitive advantage, accurate knowledge

management could help organizations to survive future pandemics. This study aimed to investigate and determine some of the influential standards that are necessary for successful knowledge management.

2.1. Headquarters System

In terms of headquarters, Laidroo and Ööbik (2013) investigated the disclosed quantity of corporate social responsibility and the transparency of banks' headquarters and argued that the patterns of disclosed quantities were different unit by unit. Furthermore, Barnes and Newton (2019) directly focused on the headquarters of the National Provincial Bank of England and demonstrated that its national identity was impressive as it differed from its rivals. Specifically, the banking industry could benefit from knowledge management and use their resources sufficiently (Cebi et al. 2010). In other words, the headquarters system recognized the inherent nature of organizations, which could facilitate their successful transformation during the pandemic. Therefore, the headquarters had to play an important role in various kinds of incentives, including hiring, promoting, and punishing, as well as enforcing rules, discouraging dissonant views and manipulating data (Broad 2007).

2.2. Human Resources

Due to the importance of the knowledge economy, human resources have been agreed upon as the most important resource for enterprises. In particular, corporate performance could be increased by improving human resources (Wu et al. 2022). Furthermore, the role of the human factor was essential in the implementation and application of the own normative system, which not only had the role of risk reduction, but also, in particular, the realization of the bank's strategies and policies. It was seen that human resource management was already a priority element of the evolutionary strategies of a modern bank (Tomescu-Dumitrescu 2020). Similarly, D'Angelo et al. (2022) also argued that human resources had to play a leading role in developing human capital management on the basis of caring, evaluating, developing, and training. Additionally, the government was required to devote time to human resource management and reach the strategic goals of the banking industry (Van Hoa et al. 2022). Human resource management was even considered to be able to mitigate barriers and ensure effective and sufficient manpower in the Banking 4.0 era (Kuchciak and Warwas 2021). Additionally, human resource managers could apply human resource information systems to make strategic decisions with the help of timely and effective information (Mohamed et al. 2022). It is no wonder that Islamic financial principles needed to be supplemented with managerial skills. This was because human resources in Islamic finance had not their reached optimal level, especially in the banking industry (Firdiansyah 2021).

2.3. Corporate Image

Nedelchev (2003) stated that corporate image could be translated into identifying the corporation and communicating with its stakeholders. Osman et al. (2015) argued that even Islamic banks needed to incorporate a corporate performance image. It could be seen that corporate image was highly important, as expected. Furthermore, it was recognized that the positive corporate image (CI) served as a major factor for the stability of the banking system (Nedelchev 2002) and that corporate image had a positive effect on financial services provided by banks (Awan et al. 2018). Ologbenla (2021) even proposed that corporate governance could be substituted by corporate image, which had a significant influence on banks' customer loyalty. In other words, banks needed corporate image to improve their competitiveness because corporate image was evaluated as more important than reputation by customers (Szwajca 2018). Furthermore, Ar and Abbas (2021b) argued that enterprises could boost their image through supporting the government and society, which could help them overcome the damaged caused by sickness and disease.

2.4. Location Advantage

Banks had to consider various problems when attempting to find a suitable location for their branches. For example, the distance from customers to the branches should be minimized. This factor determined the customers' attraction to the banks (Talatahari et al. 2022). Heard et al. (2017) also proposed that location decisions were important for local banks, and suggested that past visits were more suitable for explaining recent visits. Taking foreign banks in Spain as an example, the location of offices might be positive or negative, depending on various types of variables (Corra-Ariass 2020). Similarly, foreign banks in China did not receive the same benefits as domestic banks. Therefore, they could not perform as well as domestic banks even if they were in the same location. As a result, the cost of the disadvantages of being a foreign bank exceeded the cost of location disadvantages (Liu et al. 2021).

2.5. Innovation and Transformation

Innovation was important for banks to respond to COVID-19, which combined both knowledge management and business strategy and affected innovation capabilities (Kien and That 2022). Similarly, Edeh et al. (2022) proposed that knowledge management had an important impact on innovation in the banking industry. Therefore, knowledge management implemented by managers was proven to increase innovation capabilities, including marketing, producing, and processing. Furthermore, the innovation performance of the accounting system had a positive effect on the business performance when managers required performance evaluations (Gazi et al. 2022a). On the other hand, the implementation of financial innovation from nonfinancial firms also had to be supported to reduce various challenges and barriers (Błach 2020). It could be seen that innovation was an important factor to determine sustainable development and played a leading role from a financial perspective (Kuś and Grego-Planer 2021).

2.6. Marketing Strategy

Interactive marketing and database marketing were the dominant roles played by banks (Choudhury et al. 2022). Ndegwa (2022) proposed that banks should employ electronic marketing strategies to increase their competitiveness in the local or international market. Özkaynar (2022) argued that banks' marketing strategies had to incorporate new technologies such as the Metaverse, Blockchain, and Cryptocurrency. Islam et al. (2022) indicated that banks could gain more from event marketing than traditional advertising because the former could generate more attention than the latter. Simultaneously, Uksumenko et al. (2017) asserted that banks needed to adapt themselves to the fast changes and made use of digital marketing services such as Internet banking, mobile banking, and ATM, to connect their customers, which could help banks promote their products effectively and reach their marketing goals (Nguru et al. 2017).

2.7. Crisis Management

Banks were asked to contribute to the stability of the market and society during the pandemic crisis. Making access to credit easier or keeping rates low were among the options (Ordonez-Ponce et al. 2022). To adapt crisis management strategies to financial crises, banks had to pay more attention to crisis management, and anti-crisis tools were consequently developed to improve management performance (Sinyagovsky 2021). Additionally, with the deterioration of the financial conditions derived from COVID-19 and military aggression in Eastern Ukraine, the anti-crisis management of banks was employed more broadly to maintain the stability of the financial market (Drahan et al. 2021). In other words, it was believed that anti-crisis management was a dominant factor to overcome these challenges and ensure stability and sustainability in the development of banks (Rushchyshyn et al. 2022). Therefore, it could be recognized that anti-crisis management required a conceptual basis, which determined how they prioritized their functions to reduce and neutralize a crisis (Kopylyuk et al. 2019). Finally, central banks had to play a significant role in

implementing crisis management and processing crisis resolution, though the crises were caused by imperfect market functioning (Singh 2018).

According to the objective, method, and findings, the seven criteria are summarized in Table 1.

Table 1. Summary of the seven criteria.

Criteria	Objective	Methods	Findings
Headquarters system	Being the first criteria of knowledge management, it was proven by the studies that banks' headquarters play an important initiative on coping with the financial crisis and pandemic.	Document analysis combined with qualitative and quantitative analysis was applied to the studies, to prevent any bias from either of analyses.	• The 2008 financial crisis is reflected in the CSR disclosure quantity and readability of banks' headquarters and subsidiaries (Laidroo and Ööbik 2013). • The headquarters of National Provincial Bank of England directly impressed its national identity (Barnes and Newton 2019). • The headquarters system recognizes the inherent organizational nature which can make successful change sooner in the post-pandemic era (Cebi et al. 2010). • The headquarters has to play a central role in some incentives in hiring, promotion, and punishing, as well as selective enforcement of rules (Broad 2007).
Human Resources	Through the studies related to human resource management, knowledge management can be strengthened to overcome the problems from COVID-19.	Document analysis combined with qualitative and quantitative analysis was applied to the studies, to prevent any bias from either of analyses.	• Improving the level of human resource management can promote the improvement of corporate performance (Wu et al. 2022). • The human resource management is already a priority element of the evolutionary strategies of a modern bank (Tomescu-Dumitrescu 2020). • Human resources in the banking industry will need to play a leading role to develop human capital management (D'Angelo et al. 2022). • The government is required to set a requirement to focus on developing human resources of the banking industry to ensure the completion of strategic goals (Van Hoa et al. 2022). • Human resource management practices are a solution to mitigate challenges and the HRM roadmap for banks will become a major guide to ensure effective workforce management (Firdiansyah 2021).
Corporate image	Because the importance of the corporate image is indisputable in any organizations, these studies confirmed the positive relationship between knowledge management and the corporate image.	Document analysis combined with qualitative and quantitative analysis was applied to the studies, to prevent any bias from either of analyses.	• The corporate image is in fact translation of the corporate identity (Nedelchev 2003). • The importance of corporate image in any organization is indisputable including those from Islamic banks (Osman et al. 2015). • The positive corporate image (CI) serves as a major factor for the stability of the banking system and the corporate image creates positive brand attitude and intention to use banking services (Nedelchev 2002). • The corporate image creates positive brand attitude and intention to use banking services (Awan et al. 2018). • The corporate image management has significant impact on customer retention of the banks (Ologbenla 2021). • The banks, whose reputation is rated better by the customers, also have a better and more coherent image in their minds (Szwajca 2018). • Enterprises could step in and support the government and provide aids to societies through their own networks, which could help them in terms of boosting their corporate image (Ar and Abbas 2021b).
Location advantage	Based on the studies associated with the location of banks, it was proven that the location decisions have an influence on the implementation of knowledge management.	Document analysis combined with qualitative and quantitative analysis was applied to the studies, to prevent any bias from either of analyses.	• Determining the location of bank branches needs to be focused under competitive conditions considering different levels of customer attraction (Talatahari et al. 2022). • The location decisions are potentially important for competition in local banking markets (Heard et al. 2017). • Location of offices is a positive variable in relation to the size of the financial market but negative in terms of the amount of foreign trade for both subsidiaries and branches (Corra-Ariass 2020). • The cost of location-based disadvantages outweighed the cost of bank-specific disadvantages for foreign banks (Liu et al. 2021).

Table 1. *Cont.*

Criteria	Objective	Methods	Findings
Innovation and transfor-mation	Exploring these studies involving in innovation, the objective is to construct the relationship between knowledge management and innovation, and the results proved that there were casual relationships between them.	Document analysis combined with qualitative and quantitative analysis was applied to the studies, to prevent any bias from either of analyses.	• Innovation is considered an important factor in banks' effectiveness and competitive advantage (Kien and That 2022). • Knowledge management has significant positive effects on innovation capability (Edeh et al. 2022). • Performance evaluation has become an essential tool for managers in the banking sector to achieve sustainable balanced scorecard systems (Gazi et al. 2022a). • Financial innovations aimed to reduce the barriers and support the implementation of financial innovations by nonfinancial firms (Błach 2020). • Innovation is an extraordinarily important determinant of the sustainable development of economies across the world (Kuś and Grego-Planer 2021).
Marketing strategy	According to these studies on marketing strategies, combining knowledge management, it's more probable for banking sector to respond to the impact of COVID-19.	Document analysis combined with qualitative and quantitative analysis was applied to the studies, to prevent any bias from either of analyses.	• Interactive marketing, as well as database marketing strategies, plays dominant roles in the success of banking business (Choudhury et al. 2022). • International environments has forced banks to adopt electronic marketing strategies to gain competitive edge (Ndegwa 2022) • The banking sector focused on technologies such as Metaverse, Blockchain, and Cryptocurrency (Özkaynar 2022). • Event marketing makes the bank more profitable than other advertising strategies (Islam et al. 2022). • Pursuing effective client policy in the context of marketing concept of the commercial bank's development strategy should be considered (Uksumenko et al. 2017). • Banking sector is adapting drastic changes in their marketing strategies by using digital marketing services (Nguru et al. 2017).
Crisis management	Facing the impact of COVID-19, banks needed to pay more attention to the crisis management. Either crisis management or anti-crisis management achieved knowledge management to solve the problems derived from the pandemic.	Document analysis combined with qualitative and quantitative analysis was applied to the studies, to prevent any bias from either of analyses.	• Banks are called to contribute to society by easing access to credit or keeping rates low (Ordonez-Ponce et al. 2022). • Banks needs to pay more attention to crisis management (Sinyagovsky 2021). • Anti-crisis management needs to be introduced because the anti-crisis management of the bank can be carried out to diagnose, prevent, neutralize and overcome crisis phenomena (Drahan et al. 2021). • Anti-crisis management is relevant and necessary to ensure an adequate level of sustainability (Rushchyshyn et al. 2022). • The priority of functioning of bank and its task in preventing and neutralizing a crisis is an approach based on the interconnection of resources, opportunities, competitive advantages and strategy (Kopylyuk et al. 2019) • If a crisis occurs, central banks play a significant role in efficient crisis management(Singh 2018).

3. The Research Methodology and Design

This research applied the CFPR process to assess the criteria required to implement KM in the banking industry. Herrera-Viedma et al. (2004) suggested the CFPR research methodology to design pairwise comparison preference predictions in decision-making models from a number of alternatives. Additionally, the research examined the consistency of the decision-making process (Herrera-Viedma et al. 2004, 2007; Wang et al. 2016b). This study presents a number of descriptive definitions and propositions as follows.

3.1. Fuzzy Preference Relations

Definition 1. *According to fuzzy preference relations P, the alternative X was expressed using a positive preference relations matrix $P \subset X \times X$ belonging to the function: $\alpha_p: X \times X \rightarrow [0, 1]$. Furthermore, $p_{ij} = \alpha_p (x_i, x_j)$ interpreted the degree of the preference intensity of the alternative x_i over x_j. If $p_{ij} = \sum_{i=1}^{n} p_{ij}$, the intimated indifference between x_i and x_j ($x_i \sim x_j$), $p_{ij} = 1$, denoted that x_i was absolutely preferred to x_j; $p_{ij} = 0$ indicates that x_j was absolutely preferred to x_i; and*

$p_{ij} > \frac{1}{2}$ *showed that x_i was preferred to x_i ($x_i > x_j$). In this research, the preference matrix P was an additive reciprocal (*Wang and Chang 2007*; *Chiclana et al. 2001*; *Herrera et al. 2001*):*

$$\mathrm{p}_{ij} + \mathrm{p}_{ji} = 1 \; \forall i, j \in \{1, 2, \ldots n\} \tag{1}$$

Proposition 1. *Considering a set of alternatives, $X = \{x_i, \ldots, x_n\}$ were related to the reciprocal multiplicative preference relations $A = (a_{ij})$ with $a_{ij} \in [\frac{1}{9}, 9]$. In addition, the parallelism of the reciprocal additive fuzzy preference relations $P = (p_{ij})$ with $p_{ij} \in [0, 1]$ was associated with the formula for A, which is stated as follows:*

$$p_{ij} = \mathrm{g}(a_{ij}) = \frac{1}{2}\left(1 + \log_9 a_{ij}\right) \tag{2}$$

3.2. Consistency of the Fuzzy Preference Relations

Proposition 2. *Let $A = (a_{ij})$ be a consistent multiplicative preference relation in which the parallel reciprocal additive fuzzy preference relation $P = g(A)$ proved the additive transitivity property.*

Proof. For $A = (a_{ij})$ to be consistent, $a_{ij} \cdot a_{jk} = a_{ik} \; \forall i, j, k$, or equivalently, $a_{ij} \cdot a_{jk} \cdot a_{ki} = 1 \; \forall i, j, k$. By assuming logarithms on both sides,

$$\log_9 a_{ij} + \log_9 a_{jk} + \log_9 a_{ki} = 0 \; \forall i, j . k. \tag{3}$$

Adding Equation (3) and dividing by Equation (2) on both sides gives:

$$\frac{1}{2}(1 + \log_9 a_{ij}) + \frac{1}{2}\left(1 + \log_9 a_{jk}\right) + \frac{1}{2}\left(1 + \log_9 a_{ki}\right) = \frac{3}{2} \; \forall i, j, k \tag{4}$$

The fuzzy preference relations $P = g(A)$, where $p_{ij} = \frac{1}{2}(1 + \log_9 a_{ij})$ affirms:

$$p_{ij} + p_{jk} + p_{ik} = \frac{3}{2} \; \forall i, j, k \tag{5}$$

Undoubtedly, $P = g(A)$ verifies the additive transitivity property. This research also considered the definition of CFPRs.   □

Definition 2. *A reciprocal additive fuzzy preference relations $P = (p_{ij})$ is consistent if:*

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \; \forall i, j, k = 1, \ldots, n \tag{6}$$

3.3. Additive Transitivity Consistency of the Fuzzy Preference Relations

This research used the term "additive consistency" to refer to the consistency of the fuzzy preference relations of the additive transitivity property.

Proposition 3. *For a reciprocal fuzzy preference relation $P = (p_{ij})$, the following statements were equivalent:*

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \; \forall i, j, k \tag{7}$$

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \; \forall i < j < k \tag{8}$$

Proposition 4. *A fuzzy preference relations $P = (p_{ij})$ is consistent if:*

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \; \forall i \leq j \leq k \tag{9}$$

Proposition 5. *The equation for a reciprocal additive fuzzy preference relation $P = (p_{ij})$ is as follows:*

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \; \forall i < j < k \tag{10}$$

$$p_{i(i+1)} + p_{(i+1)(i+2)} + \ldots + p_{(j-1)j} + p_{ji} = \frac{j-i+1}{2} \; \forall i < j \tag{11}$$

The research established pairwise comparison matrices for *n* criteria (C_i, $i = 1, 2, \ldots, n$) in a hierarchical system. This provided the essential equations and decision matrices as follows:

$$A^k = \begin{array}{c} \\ c_1 \\ c_2 \\ \vdots \\ c_{n-1} \\ c_n \end{array} \begin{array}{c} c_1 \quad c_2 \quad \ldots \quad c_{n-1} \quad c_n \\ \begin{bmatrix} 1 & a^k_{12} & \ldots & \times & \times \\ \times & 1 & a^k_{23} & \times & \times \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ \times & \times & \ldots & 1 & a^k_{(n-1)n} \\ \times & \times & \ldots & \times & 1 \end{bmatrix} \end{array} \tag{12}$$

The preference value a^k_{ij} in p^k_{ij} utilized an interval scale $[0, 1]$. Then, the preserved p^k_{ij} that was derived relied on the reciprocal transitivity property, as follows:

$$A^k \overset{\frac{1}{2}(1+\log_9 a_{ij})}{\Rightarrow} = p^k \begin{array}{c} \\ c_1 \\ c_2 \\ \vdots \\ c_n \end{array} \begin{array}{c} c_1 \quad\quad c_2 \quad\quad \ldots \quad c_n \\ \begin{bmatrix} 0.5 & p^k_{12} & \times & \times \\ 1 - p^k_{12} & 0.5 & p^k_{23} & \times \\ \vdots & 1 - p^k_{12} & \vdots & \vdots \\ \times & \times & \ldots & 0.5 \end{bmatrix} \end{array} \tag{13}$$

The transformation function (x) was stated as follows (Herrera-Viedma et al. 2004):

$$f : [-a, 1+a] \rightarrow [0, 1]$$

$$f : [-a, 1+a] \rightarrow [0, 1]$$

$$f(x) = \frac{x + a}{1 + 2a}$$

The transformation function was formulated as follows (Wang et al. 2016a):

$$f\left(p^k_{ij}\right) = \frac{p^k_{ij} + a}{1 + 2a} \tag{14}$$

The notation for the average integrated values of *m* evaluators was:

$$p_{ij} = \frac{1}{m}\left(p^1_{ij} + p^2_{ij} + \ldots + p^m_{ij}\right) \tag{15}$$

Normalized fuzzy preference relation matrix q_{ij} was aggregated to present the normalized fuzzy preference value for each criterion as follows:

$$q_{ij} = \frac{1}{n}\sum_{i=1}^{n} p_{ij} \tag{16}$$

The number of influential criteria and priority of each criterion could be defined as follows:

$$\overline{\omega}_i = \frac{q_{ij}}{\sum_{i=1}^{n} q_{ij}} \tag{17}$$

This study illustrated the application of Equation (1) to (17), which analyzed the collected data and ranked the outcomes. The pairwise comparisons presented the priority weights, which in turn assessed how the stakeholders applied accurate research to support the banking industry during the pandemic. This study applied all 23 equations to analyze the responses of the experts and ranked the two outcomes for a set of $t-1$ preference data $\{b_{12}, b_{23}, \ldots, b_{(t-1)t}\}$, as follows. The prediction weight 0.5 denoted approximately a fifty/fifty probability of success or failure of implementing knowledge management. Accordingly, the study applied Equations (1) to (23) to evaluate essential applications to deal with the pandemic.

4. Research for KM Implementation

4.1. Evaluated Influential Criteria and Framework of the Evaluation Model

CFPRs were applied to demonstrate a hierarchical prediction model (see Figure 1), and help the banking industry decrease the impact of the pandemic (Wang and Chang 2007). The pairwise comparisons were calculated and ranked to obtain the priority weights of the seven criteria and two outcomes, and then we rated which would be the best KM implementations for banking sectors to adopt (Li et al. 2016; Hsieh et al. 2020).
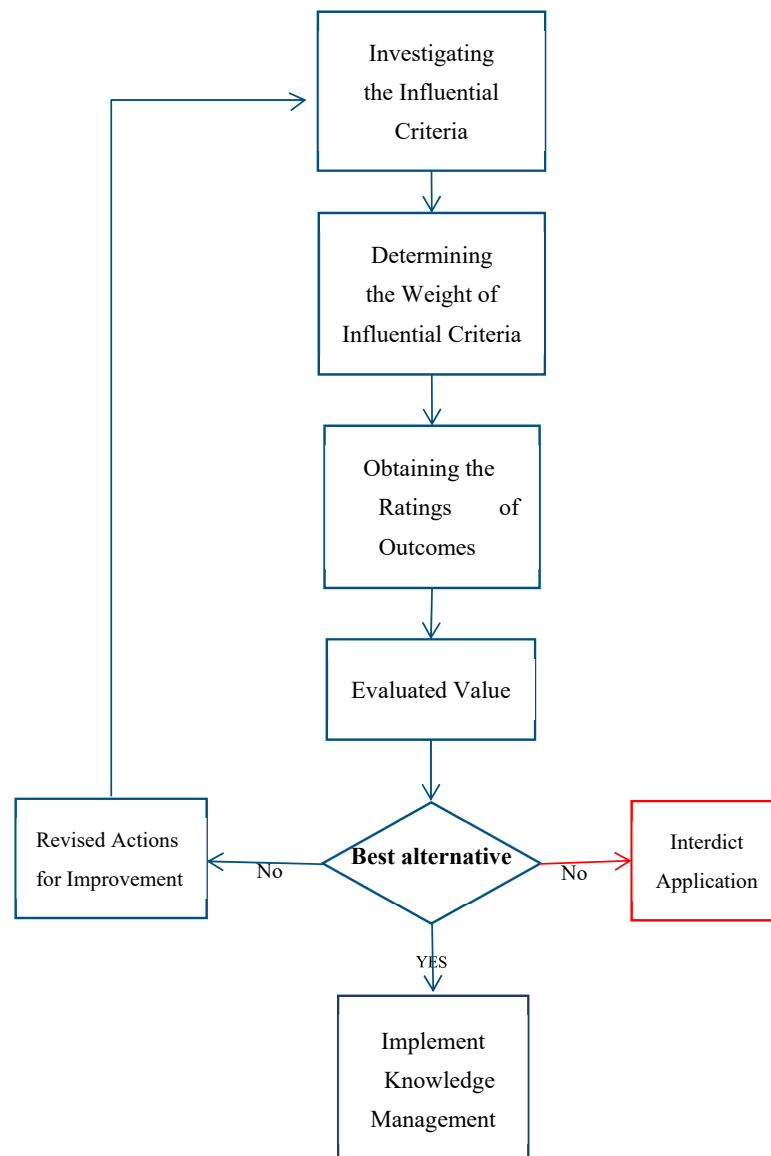
Figure 1. The framework of knowledge management research. Source: Hsieh et al. (2020).

Fifteen banking experts were assessed through interviews and questionnaires, which included eight managers and seven scholars from the Taiwan banking industry. Evaluators had been involved in the banking field for between sixteen and thirty-one years, and had in-depth experience dealing with the COVID-19 situation.

Predictions using the KM model may help the banking industry to overcome this unprecedented crisis. Experts assessed KM criteria and attributes that influenced the likelihood of business success. These criteria were as follows: C_1 the headquarters system; C_2 human resources; C_3 corporate image; C_4 location advantages; C_5 innovation and transformation; C_6 the marketing strategy, and C_7 crisis management. An analytical hierarchy framework depending on the seven criteria is shown in Figure 2 (Wang and Chang 2007; Wang et al. 2016b; Hsieh et al. 2020).
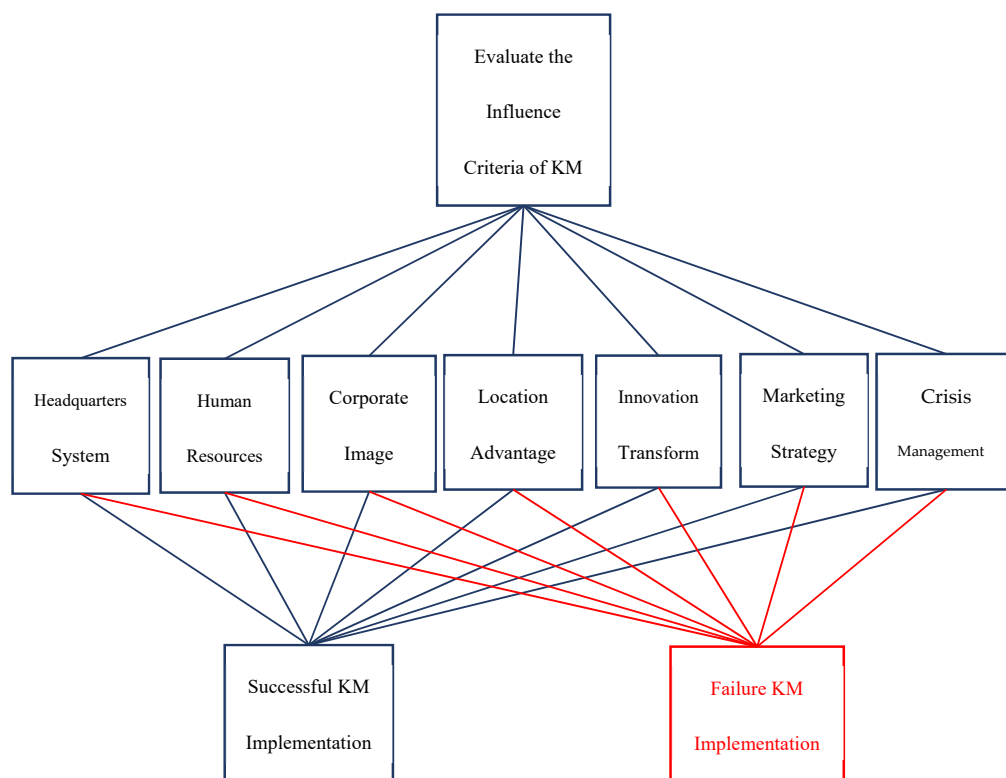
Figure 2. The analytical hierarchy framework. Source: Hsieh et al. (2020).

4.2. The Hierarchy Analytical Process for Evaluating Criteria Influence

4.2.1. Linguistic Variables

This study compared criterion pairs by means of employing linguistic variables such as "Equally important (EQ)", "Weakly important (WK)", "Strongly important (ST)", "Very strongly important (VS)", and "Absolutely important (AB)", as well as by applying a nine-level scale with values indicated by actual numbers (see Table 2).

Table 2. Linguistic variables for priority weights of influential criteria.

Definition	Intensity of Importance
Equally important (EQ)	1
Weakly important (WK)	3
Strongly important (ST)	5
Very strongly important (VS)	7
Absolutely important (AB)	9
Intermediate values used to represent a compromise	2,4,6,8

Additionally, the linguistic variables "Very high (VH)", "High (H)", and "Fair (F)" were applied to predict the probability of success or failure for the seven criteria (see Table 3).

Table 3. Linguistic variables for the priority rating of possible outcome.

Definition	Intensity of Importance
Fair (F)	1
High (H)	3
Very High (VH)	5
Intermediate values used to represent a compromise	2,4

4.2.2. Defining the Priority Ratings for Possibility of Outcome Compliance with Each Criterion

The evaluators offered subjective evaluations, examining the preference ratings of possible outcomes Au (u = 1, 2, . . . , t) and indicating each influential criterion as a linguistic variable, as shown in Table 2.

(1) For each influential criterion, the evaluators selected two possible outcomes, for a set of $t - 1$ preference data $\{b_{12}, b_{23}, \ldots, b_{(t-1)t}\}$ (Wang et al. 2016a); for instance:

$$
{}_iB = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_{t-1} \\ A_t \end{array}
\begin{array}{c} A_1 \quad A_2 \quad \ldots \quad A_{t-1} \quad A_t \end{array}
\begin{bmatrix}
1 & {}_ib^k_{12} & \times & \times & \times \\
\times & 1 & {}_ib^k_{23} & \times & \times \\
\vdots & \vdots & \ddots & \ddots & \vdots \\
\times & \times & \ldots & 1 & {}_ib^k_{(t-1)t} \\
\times & \times & \ldots & \times & 1
\end{bmatrix}
\tag{18}
$$

where ${}_ib^k_{uv}$ indicates the evaluated value assigned by Evaluator k to calculate the possible outcomes, Au and Av, and relies on influential criterion i.

(2) The preference value ${}_ib^k_{uv}$ is transformed for the range $\left[\frac{1}{5}, 5\right]$ into ${}_iq^k_{uv}$ in an interval scale [0, 1], and the reserve ${}_iq^k_{uv}$ can be acquired utilizing the reciprocal transitivity property, as follows:

$$
{}_iB \overset{\frac{1}{2}(1+\log_5 b_{uv})}{\Rightarrow} {}_iQ =
\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_{t-1} \\ A_t \end{array}
\begin{array}{c} A_1 \qquad A_2 \qquad \ldots \quad A_{t-1} \quad A_t \end{array}
\begin{bmatrix}
0.5 & {}_iq^k_{12} & \times & \times & \times \\
1 - {}_iq^k_{12} & 0.5 & {}_iq^k_{23} & \times & \times \\
\vdots & 1 - {}_iq^k_{23} & \ddots & \ddots & \vdots \\
\times & \times & \ldots & 0.5 & {}_iq^k_{(t-1)t} \\
\times & \times & \ldots & \times & 0.5
\end{bmatrix}
\tag{19}
$$

(3) The suggestions of evaluators were obtained to rate the synthetically transformed possible outcomes. The ${}_iq^k_{uv}$ value represents the transformed fuzzy preference value of Evaluator k for evaluating the possible outcomes, Au and Av, in terms of influential criterion i. The average value integrated the assessment values of m evaluators:

$$
{}_iq^k_{uv} = \frac{1}{m}\left({}_iq^1_{uv} + {}_iq^2_{uv} + \ldots + {}_iq^m_{uv}\right),
\tag{20}
$$

where m evaluators participated in the evaluation process.

(4) The synthetically normalized fuzzy preference rating of possible outcomes took ${}_i\lambda_{uv}$ to represent the normalized rating of the possible outcomes, Au and Av, for influential criterion i, for instance:

$$
{}_i\lambda_{uv} = \frac{{}_iq_{uv}}{\sum\limits_{u=1}^{t} {}_iq_{uv}} \quad u, v = 1, 2, \ldots t.
\tag{21}
$$

(5) As a consequence, $_i\overline{\phi_u}$ represents the average rating of possible outcome Au with respect to influential criterion i. The appetence rating of each possible outcome could be acquired, as follows:

$$_i\overline{\phi_u} = \frac{1}{t}\sum_{v=1}^{t}\lambda_{uv},\qquad(22)$$

where t presents the number of possible outcomes.

4.2.3. Acquiring the Priority Weight for Prediction

The priority weights were multiplied by the possible outcomes to acquire the predicted value Zu for the probability of success or failure.

$$Z_u = \sum_{i=1}^{n} {}_i\overline{\phi_u}\,\overline{\omega_i},\qquad(23)$$

where $\overline{\omega_i}$ indicates the aggregated weight of influential criterion i, and $_i\overline{\phi_u}$ denotes the rating of the possible outcome Au with respect to influential criterion i. The prediction weight 0.5 denoted approximately a fifty/fifty probability of either success or failure for the KM implementation.

4.3. Empirical Case for Predicting Possibility of Success of Implementing KM

This study demonstrated the implementation of KM in the banking sectors in the post-COVID-19 era in order to illustrate an analytic framework. Questionnaires and surveys of experts were conducted to investigate the real-world situation of the COVID-19 pandemic.

4.3.1. Weight Calculation of the Influential Criteria

(1) Based on the interviews of the 15 experts, seven influential criteria were identified (see Table 4) and n pairwise comparison matrices were developed from $n-1$ contiguous criteria $\{a_{12}, a_{23}, \ldots, a_{78}\}$ into linguistic terms (Wang et al. 2016a).

Table 4. The linguistic terms used when referring to seven criteria evaluated by 15 experts in Taiwan.

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	E_{13}	E_{14}	E_{15}	
C1	LSLV	LVLA	VS	VS	SW	LVS	ST	VS	EQ	VS	ST	VS	AB	VS	VS	C2
C2	LST	AV	LVLA	ST	ST	VS	ST	VT	VS	LVS	WK	VT	VS	SW	ST	C3
C3	VS	AV	AV	EQ	SW	EQ	VS	SW	EQ	VS	ST	ST	WE	LVS	WK	C4
C4	LVS	LVLA	LSLV	LST	SW	LVLA	WK	LVS	VS	LVS	LVS	LSLV	SW	EQ	LVS	C5
C5	ELW	AV	LVS	LST	SW	SW	LST	LVS	EQ	LVS	EQ	VT	LVS	EQ	SW	C6
C6	LSLV	LVLA	LST	LST	LSLV	LAB	WK	VT	LAB	LVS	ST	LVS	ST	WK	LVS	C7
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	E_{13}	E_{14}	E_{15}	

(2) The assessment of the first evaluator (E1) can be used as an example (see Table 5). The fuzzy preference values are presented in Table 1, and the linguistic terms were transformed into parallel scores, as shown in Table 6.

Table 5. Fuzzy preference pairwise comparisons matrix of evaluator 1 in Taiwan.

E_1	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	1.0000	LSLV					
C_2		1.0000	LST				
C_3			1.0000	VS			
C_4				1.0000	LVS		
C_5					1.0000	ELW	
C_6						1.0000	LSLV
C_7							1.0000

E_1	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	1.0000	1/6	×	×	×	×	×
C_2	×	1.0000	1/5	×	×	×	×
C_3	×	×	1.0000	7	×	×	×
C_4	×	×	×	1.0000	1/7	×	×
C_5	×	×	×	×	1.0000	1/2	×
C_6	×	×	×	×	×	1.0000	1/6
C_7	×	×	×	×	×	×	1.0000

(3) The linguistic terms were transformed into parallel scores.

(4) Transforming the elements by applying Equation (2) (listed in Table 5) into an interval [0, 1] provides the following:

$$p_{12} = (1 + log_9 0.1667)/2 = 0.0923,$$

$$p_{23} = (1 + log_9 0.2000)/2 = 0.1338,$$

$$p_{34} = (1 + log_9 7.0000)/2 = 0.9428,$$

$$p_{45} = (1 + log_9 0.1428)/2 = 0.0572$$

$$p_{56} = (1 + log_9 0.5000)/2 = 0.3423$$

$$p_{67} = (1 + log_9 0.1667)/2 = 0.0923$$

The evaluation score could then be calculated by applying Equations (1) and (11), utilizing $p_{21}, p_{31}, p_{71}, p_{72}$, and p_{27} as follows:

$$p_{21} = 1 - p_{12} = 1 - 0.0923 = 0.9077$$

$$p_{31} = \frac{3 - 1 + 1}{2} - p_{12} - p_{23} = 1.5 - 0.0923 - 0.1338 = 1.2740$$

$$p_{71} = \frac{7-1+1}{2} - p_{12} - p_{23} - p_{34} - p_{45} - p_{56} - p_{67}$$
$$= 3.5 - 0.0923 - 0.1338 - 0.9428 - 0.0572 - 0.3423 - 0.0923$$
$$= 1.8394$$

$$p_{72} = \frac{7-2+1}{2} - p_{23} - p_{34} - p_{45} - p_{56} - p_{67}$$
$$= 3 - 0.1338 - 0.9428 - 0.0572 - 0.3423 - 0.0923$$
$$= 1.4317$$

$$p_{27} = 1 - p_{72} = 1 - 1.4317 = -0.4317$$

The fuzzy preference relation matrix for the seven influential criteria evaluated by E1 is shown in Table 7.

Table 7. Consistent fuzzy preference relation matrix of criteria evaluated by E1 in Taiwan.

E_1	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	0.5000	0.0923	−0.2740	0.1688	−0.2740	−0.4317	−0.8394
C_2	0.9077	0.5000	0.1338	0.5766	0.1338	−0.0240	−0.4317
C_3	1.2740	0.8662	0.5000	0.9428	0.5000	0.3423	−0.0655
C_4	0.8312	0.4234	0.0572	0.5000	0.0572	−0.1005	−0.5083
C_5	1.2740	0.8662	0.5000	0.9428	0.5000	0.3423	−0.0655
C_6	1.4317	1.0240	0.6577	1.1005	0.6577	0.5000	0.0923
C_7	1.8394	1.4317	1.0655	1.5083	1.0655	0.9077	0.5000

Table 6 lists p_{13}, p_{31}, p_{15}, p_{51}, p_{16}, p_{61}, p_{17}, p_{71}, p_{26}, p_{62}, p_{27}, p_{72}, p_{37}, p_{73}, p_{46}, p_{64}, p_{47}, p_{74}, p_{57}, and p_{75} elements as not being found in the interval [0, 1]. Therefore, Equation (14)

was a linear transformation that could be applied to confirm the reciprocity and additive transitivity of the preference relations matrix (see Table 8).

Table 8. Linear solution for transformation matrix of criteria in Taiwan.

E_1	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	0.5000	0.3478	0.2111	0.3764	0.2111	0.1522	0.0000
C_2	0.6522	0.5000	0.3633	0.5286	0.3633	0.3044	0.1522
C_3	0.7889	0.6367	0.5000	0.6653	0.5000	0.4411	0.2889
C_4	0.6236	0.4714	0.3347	0.5000	0.3347	0.2758	0.1236
C_5	0.7889	0.6367	0.5000	0.6653	0.5000	0.4411	0.2889
C_6	0.8478	0.6956	0.5589	0.7242	0.5589	0.5000	0.3478
C_7	1.0000	0.8478	0.7111	0.8764	0.7111	0.6522	0.5000

(5) The calculated procedures illustrated the fuzzy preference relations matrices of the other 14 evaluators. The aggregated pairwise comparison matrix of the 15 evaluators was acquired by applying Equation (15), as shown in Table 9.

Table 9. Aggregated pairwise comparison matrices of 15 evaluators in Taiwan.

E	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	0.5000	0.5896	0.7114	0.8127	0.7108	0.6999	0.6411
C_2	0.4104	0.5000	0.6219	0.7231	0.6212	0.6103	0.5515
C_3	0.2886	0.3781	0.5000	0.6013	0.4993	0.4885	0.4297
C_4	0.1873	0.2769	0.3987	0.5000	0.3981	0.3872	0.3284
C_5	0.2892	0.3788	0.5007	0.6019	0.5000	0.4891	0.4303
C_6	0.3001	0.3897	0.5115	0.6128	0.5109	0.5000	0.4412
C_7	0.3589	0.4485	0.5703	0.6716	0.5697	0.5588	0.5000
Total	2.3345	2.9614	3.8146	4.5234	3.8100	3.7338	3.3222

(6) Equation (16) was applied to normalize the aggregated pairwise comparison matrix. Using q_{12} as an example:

$$q_{12} = 0.5896/(0.5896 + 0.5000 + 0.3781 + 0.2769 + 0.3788 + 0.3897 + 0.4485) = 0.1991$$

The priority weight of every influential criterion was acquired by applying Equation (17). The priority weight and rank of every influential criterion from the 15 evaluators are presented as Table 10.

Table 10. Normalized matrix of priority weight and rank of influential criteria in Taiwan.

E	C_1	C_2	C_3	C_4	C_5	C_6	C_7	Total	Weight	Ranking
C_1	0.2142	0.1991	0.1865	0.1797	0.1866	0.1874	0.1930	1.3464	0.1861	1
C_2	0.1758	0.1688	0.2100	0.1599	0.1631	0.1635	0.1660	1.2070	0.1668	2
C_3	0.1236	0.1277	0.1688	0.1329	0.1311	0.1308	0.1293	0.9442	0.1305	6
C_4	0.0802	0.0935	0.1346	0.1105	0.1045	0.1037	0.0988	0.7259	0.1003	7
C_5	0.1239	0.1279	0.1691	0.1331	0.1312	0.1310	0.1295	0.9457	0.1307	5
C_6	0.1285	0.1316	0.1727	0.1355	0.1341	0.1339	0.1328	0.9691	0.1340	4
C_7	0.1537	0.1514	0.1926	0.1485	0.1495	0.1497	0.1505	1.0959	0.1515	3
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	7.2344	1.0000	

The ranked weights of the influential criteria are as follows:
C_1 the headquarters system (0.1861) > C_2 human resources (0.1668)
C_7 crisis management (0.1515) > C_6 the marketing strategy (0.1340) >

C_5 innovation and transformation (0.1307) $>$ C_3 corporate image (0.1305) $>$ C_4 the location advantage (0.1003).

The results indicated that the three most important influential criteria identified by the experts were the headquarters system (0.1861), human resources (0.1668), and crisis management (0.1515), and the four least important criteria were marketing strategy (0.1340), innovation and transformation (0.1307), corporate image (0.1305), and location advantage (0.1003).

4.3.2. The Influential Criteria were Calculated to Acquire Weights for Possibilities of Outcomes

Each influential criterion in the banking sector was evaluated for its ability to implement KM and increase the probability of success (Yeung et al. 2016). The linguistic terms used by experts to determine the priority weight matrix of possible outcomes for each criterion are shown in Table 2. The prediction values of the two possible outcomes were analyzed as follows:

(1) To assess the real-world situation for the banking sector during the pandemic period, the 15 experts were interviewed and asked to evaluate which influential criteria were most essential. Table 11 indicates the selections made by the 15 experts in terms of their preference for increasing the probability of success according to each influential criterion.

Table 11. Linguistic variables assigned to the priority weights of the two possible outcomes in Taiwan.

		E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	E_{13}	E_{14}	E_{15}
		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
C1	s	HF	VHG	VH	H	H	H	H	H	F	VHG	H	VHG	VH	VHG	VHG
C2	s	VHG	VHG	H	F	H	VHG	VHG	H	VHG	HF	LHF	VHG	VH	H	VHG
C3	s	H	VHG	VH	LH	H	LHF	H	HF	LVH	VHG	H	H	H	H	H
C4	s	F	VHG	HF	VHG	VHG	F	F	H	VHG	F	LHF	H	VHG	LH	H
C5	s	VHG	LHF	H	F	LHF	H	H	VHG	HF	F	VHG	VHG	H	HF	H
C6	s	VHG	H	H	H	H	F	VHG	VHG	VHG	VHG	VHG	H	VHG	HF	H
C7	s	VH	H	VHG	F	HF	H	H	HF	LVHG	VHG	H	VH	F	LVHG	VHG

Note: S and F indicate the abbreviated success and failure, respectively.

(2) The process for translating the linguistic variables into parallel numbers is illustrated in Table 2. The function ${}_i q_{uv}^k = \frac{1}{2}\left(1 + \log_5 {}_i b_{uv}^k\right)$ was applied to transform the values on a scale of $[\frac{1}{5}, 5]$ into the interval $[0, 1]$. The preference data were transformed into the possible outcomes of success, as shown in Table 12.

Table 12. Transformed preference weight for possible outcome of "success" in Taiwan.

		E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	E_{13}	E_{14}	E_{15}		q_{SF}
		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	Total	Average
C1	s	0.7153	0.9307	1.0000	0.8413	0.8413	0.8413	0.8413	0.8413	0.5000	0.9307	0.8413	0.9307	1.0000	0.9307	0.9307	12.9165	0.8611
C2	s	0.9307	0.9307	0.8413	0.5000	0.8413	0.9307	0.9307	0.8413	0.9307	0.7153	0.2847	0.9307	1.0000	0.8413	0.9307	12.3799	0.8253
C3	s	0.8413	0.9307	1.0000	0.1587	0.8413	0.2847	0.8413	0.7153	0.0000	0.9307	0.8413	0.8413	0.8413	0.8413	0.8413	10.7505	0.7167
C4	s	0.5000	0.9307	0.7153	0.9307	0.9307	0.5000	0.5000	0.8413	0.9307	0.5000	0.2847	0.8413	0.9307	0.1587	0.8413	10.3360	0.6891
C5	s	0.9307	0.2847	0.8413	0.5000	0.2847	0.8413	0.8413	0.9307	0.7153	0.5000	0.9307	0.9307	0.8413	0.7153	0.8413	10.9292	0.7286
C6	s	0.9307	0.8413	0.8413	0.8413	0.8413	0.5000	0.9307	0.9307	0.9307	0.9307	0.9307	0.8413	0.9307	0.7153	0.8413	12.7779	0.8519
C7	s	1.0000	0.8413	0.9307	0.5000	0.7153	0.8413	0.8413	0.7153	0.0693	0.9307	0.8413	1.0000	0.5000	0.0693	0.9307	10.7266	0.7151

(3) The reciprocal additive transitivity property was applied, and the opposite comparison was made for failure, as shown in Table 13.

Table 13. Opposite comparison matrix for possible outcomes of "failure" in Taiwan.

| | | E_1 | E_2 | E_3 | E_4 | E_5 | E_6 | E_7 | E_8 | E_9 | E_{10} | E_{11} | E_{12} | E_{13} | E_{14} | E_{15} | | q_{FS} |
		s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	Total	Average
C1	F	0.2847	0.0693	0.0000	0.1587	0.1587	0.1587	0.1587	0.1587	0.5000	0.0693	0.1587	0.0693	0.0000	0.0693	0.0693	2.0835	0.1389
C2	F	0.0693	0.0693	0.1587	0.5000	0.1587	0.0693	0.0693	0.1587	0.0693	0.2847	0.7153	0.0693	0.0000	0.1587	0.0693	2.6201	0.1747
C3	F	0.1587	0.0693	0.0000	0.8413	0.1587	0.7153	0.1587	0.2847	1.0000	0.0693	0.1587	0.1587	0.1587	0.1587	0.1587	4.2495	0.2833
C4	F	0.5000	0.0693	0.2847	0.0693	0.0693	0.5000	0.5000	0.1587	0.0693	0.5000	0.7153	0.1587	0.0693	0.8413	0.1587	4.6640	0.3109
C5	F	0.0693	0.7153	0.1587	0.5000	0.7153	0.1587	0.1587	0.1587	0.2847	0.5000	0.0693	0.0693	0.2847	0.1587	4.0708	0.2714
C6	F	0.0693	0.1587	0.1587	0.1587	0.1587	0.5000	0.0693	0.0693	0.0693	0.0693	0.0693	0.1587	0.0693	0.2847	0.1587	2.2221	0.1481
C7	F	0.0000	0.1587	0.0693	0.5000	0.2847	0.1587	0.1587	0.2847	0.9307	0.0693	0.1587	0.0000	0.5000	0.9307	0.0693	4.2734	0.2849

(4) The rating of possible outcomes was synthetically acquired by applying Equation (20), as shown in Table 14. Equations (21) and (22) could then be applied to synthesize and normalize the fuzzy preference ratings of the possible outcomes, relying upon the seven influential criteria. The normalized values and priority weights are listed in Table 15.

Table 14. Normalized values and priority weights of possible outcomes relying on seven criteria in Taiwan.

		Success	**Failure**	**Total**	**Average**
c_1	Success	0.7826	0.6327	1.4152	0.7076
	Failure	0.2174	0.3673	0.5848	0.2924
c_2	Success	0.7411	0.6227	1.3638	0.6819
	Failure	0.2589	0.3773	0.6362	0.3181
c_3	Success	0.6383	0.5891	1.2274	0.6137
	Failure	0.3617	0.4109	0.7726	0.3863
c_4	Success	0.6166	0.5795	1.1961	0.5980
	Failure	0.3834	0.4205	0.8039	0.4020
c_5	Success	0.6482	0.5930	1.2412	0.6206
	Failure	0.3518	0.4070	0.7588	0.3794
c_6	Success	0.7714	0.6301	1.4016	0.7008
	Failure	0.2286	0.3699	0.5984	0.2992
c_7	Success	0.6370	0.5885	1.2255	0.6128
	Failure	0.3630	0.4115	0.7745	0.3872

Table 15. Prediction of "success" and "failure" probabilities in Taiwan.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	**Prediction Probability**
Rank	1	2	6	7	5	4	3	
priority Weight	0.1861	0.1668	0.1305	0.1003	0.1307	0.1340	0.1515	1.0000
Success	0.7076	0.6819	0.6137	0.5980	0.6206	0.7008	0.6128	0.6534
Failure	0.2924	0.3181	0.3863	0.4020	0.3794	0.2992	0.3872	0.3466

4.3.3. Determining the Prediction Values of Priority Weight

Appling Equation (23), two possible outcomes were calculated by multiplying the priority weight, and the prediction weights determined the probabilities of success and failure from KM implementation, as shown in Table 14. For instance, the prediction weight was calculated as follows:

$$\text{Zsuccess} = (0.1861 \times 0.7076) + (0.1668 \times 0.6819) + (0.1305 \times 0.6137) + (0.1003 \times 0.5980) + (0.1307 \times 0.6206) + (0.1340 \times 0.7008) + (0.1515 \times 0.6128) = 0.6534,$$

$$\text{Zfailure} = (0.1861 \times 0.2924) + (0.1668 \times 0.3181) + (0.1305 \times 0.3863) + (0.1003 \times 0.4020) + (0.1307 \times 0.3794) + (0.1340 \times 0.2992) + (0.1515 \times 0.3872) = 0.3466$$

5. Discussion and Implications of the Study

5.1. Discussion

The empirical results showed that C1 the headquarters system (0.1861), C2 the human resource advantage (0.1668), and C7 crisis management (0.1515) were the three most important indicators for the banking industry to facilitate knowledge management and increase the probability of business success. The less important indicators were marketing strategy C6 (0.1340), C5 innovation and transformation (0.1307), C3 corporate image (0.1305), and C4 location advantage (0.1003) (see Tables 9 and 14).

However, after analyzing the predictions obtained from the questionnaires of experts and scholars, it was also found that the seven indicators that affected the successful implementation of the KM model were C1 the headquarters system (0.7076), C2 human resources (0.6819), C6 the marketing strategy (0.7008), C5 innovation and transformation (0.6206), C3 corporate image (0.6137), C7 crisis management (0.6128), and C4 the location advantage (0.5980). Among them, C1 the headquarters system (0.7076), C6 the marketing strategy (0.7008), and C2 human resources (0.6819) were more influential than the other four indicators to implement KM successfully (see Table 14).

On the contrary, the seven index values that were expected to cause the implementation of the knowledge management model to fail were C1 the headquarters system (0.2924), C2 human resources (0.3181), C3 corporate image (0.3863), C4 the location advantage (0.4020), C5 innovation and transformation (0.3794), C6 the marketing strategy (0.2992), and C7 crisis management (0.3872) (Table 14). Again, it is worth noting that the four indicators included—C4 location advantage (0.4020), C7 crisis management (0.3872), C3 corporate image (0.3863), and C5 innovation and transformation (0.3794)—probably failed to implement knowledge management successfully.

Based on Table 14, it was proven that the successful indicators for the banking industry to facilitate KM implementation were different, with or without multiplying the priority weight and predicting weights of the probabilities of success and failure from knowledge management implementation. However, the predictions of success probabilities (0.6354) were higher than those of failure probabilities (0.3466) among the seven influential criteria. In other words, the predictions of success probabilities (0.6354) were higher than those of failure probabilities (0.3466) among the seven influential criteria. Therefore, predictions of success probabilities needed to be emphasized to implement knowledge management within the banking industry in Taiwan after weighing the probabilities of success and failure.

Interestingly, though C7 crisis management was listed as an important priority indicator to conduct knowledge management, it was not listed in either the priority indicator of the successful implementation of the knowledge management model or the failure of the implementation of knowledge management. The result implied that, compared to other countries, the banking industry in Taiwan was more conscious of the threat of the pandemic and understood how to respond to it.

5.2. Implications of the Study

The results of the above discussion showed that the probability of the successful implementation of knowledge management was higher than that of failure to do so. More specifically, both C1 the headquarters system and C2 human resources were regarded as the most important indicators among the seven criteria when considering the probability of the successful implementation of knowledge management. This study contributes to various industries and policymakers theoretically and practically because the results explicitly revealed that there was an alternative to the traditional countermeasures when coping with the unprecedented pandemic effectively and efficiently, especially when they were also knowledge-intensive industries.

6. Conclusions and Limitations

6.1. Conclusions

Facing the challenges derived from COVID-19, the banking industry in Taiwan has adopted various measures to respond to the threat of the pandemic, but it seemed that the problem had not changed or improved obviously. Based on knowledge management and applying consistent fuzzy preference relations (CFPRs), it was found that the results of the study can practically or theoretically contribute to other industries in Taiwan.

According to the earlier studies in the paper, the most commonly used countermeasures were financial digitalization technology, including Fintech online payment and big data from the FinTech website, and corporate governance, which had been revealed as the moderator of knowledge management, business strategy, and innovation capabilities. It is clear that these studies focused on partial countermeasures, such as headquarters, human resources or innovation, but did not employ knowledge management combined with the seven criteria to respond to the pandemic. In other words, in contrast to the practical measures to respond to the pandemic, such as adopting social distancing, isolation periods, and vaccinations, the study highlighted the importance of implementing knowledge management through seven influential criteria applied in the banking industry in Taiwan, which were found to have made significant contributions, as follows.

First, the initial result showed that the headquarters system, human resource advantage, and crisis management are the three most important indicators for the banking industry to facilitate knowledge management (see Table 9). Second, considering the prediction of success probabilities, the headquarters system, the marketing strategy, and human resources are more influential than the other four indicators for the successful implementation of knowledge management. Conversely, the headquarters system and human and crisis management are more influential than the other indicators when considering the probability of failure to implement knowledge management (see Table 14). Third, the predictions of success probabilities are higher than those of failure probabilities among the seven influential criteria (see Table 14). This means that predictions of success probabilities need to be emphasized to implement knowledge management if the banking industry in Taiwan wants to survive or succeed in their business operations.

Specifically, according to the analysis in the Discussion section and its results, it is concluded that the headquarters system and human resources are the most important priority indicators among the seven influential criteria, which could help reduce the gap in knowledge because they both show the ability to ensure the successful implementation of knowledge management in the banking industry in Taiwan. Furthermore, due to Taiwan's outstanding performance in managing the pandemic in its earlier stage, crisis management was not prominent in the criteria of knowledge management, which also represents another gap in the knowledge. This implied the significant policy implications within the banking industry and other industries because it has been proven that knowledge management can be employed as an alternative to the traditional tools of financial technologies or corporate governance to cope with the pandemic effectively and efficiently.

6.2. Limitations and Future Work

In spite of the study's substantial contributions, future research is needed to face several limitations. First, this study aimed to explore the banking industry in Taiwan during the pandemic period. As such, it is suggested that future studies should be expanded to compare other kinds of countries or industries. Second, owing to the pandemic, this study conducted 15 expert surveys. Therefore, it is suggested that future research should increase the sample size to promote the survey's level representativeness. Third, though the pandemic situation has improved gradually in some countries, knowledge management still faces some difficulties and uncertainty. In other words, the financial industry, especially the banking industry, lacks successful knowledge management practices, which restricts business performance. Knowledge management researchers must recognize this phenomenon in order to build sustainable performance and competitive advantages within

the banking industry or service sectors. Since the findings revealed successful knowledge management strategies for the banking industry, it is clear that they should also be considered within other industries as a mechanism to improve competitiveness. This study encourages researchers to carry out more in-depth studies in similar fields.

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