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Critical Factors Considered by Companies to Introduce Business Intelligence Systems

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Abstract: The advent of intelligent technology has spurred most large companies to introduce business intelligence systems (BIS), but those with low information maturity still have a wait-and-see attitude towards BIS. In order to accelerate the introduction of BIS, this study found and analyzed the critical factors (CFs) considered by companies when introducing BIS. First, the literature on factors considered by companies to introduce BIS was reviewed. The three stages before, during, and after introduction in marketing that organizations undergo during the procurement process were developed into a three-layer hierarchy factor table. An expert questionnaire with pairwise factors was then designed and sent to senior executives in companies that had introduced BIS, and the weights of all factors were calculated by the fuzzy analytic hierarchy process (FAHP) based on the collected questionnaire data. After this, four critical factors—system function integrity, approaching corporate strategy, licensing fee, and information technology maturity—were determined objectively by using the conditions for the acceptable advantage of Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR) and further explored in order to help companies input fewer resources, introduce BIS efficiently, and thus increase their decision-making power.

Keywords: business intelligence systems (BIS); critical factors (CFs); procurement process; fuzzy analytic hierarchy process (FAHP); Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR)

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1. Introduction

With the development of intelligent technology and the great changes in its applications, corporations are facing greater market competition and pressure, and their decision-making and reaction abilities are becoming more and more challenging to maintain. However, a great deal of manpower and time is required to collect internal and external structured and unstructured data from companies through various analytical statements and forecast trends. It is also difficult to integrate operating statements and data of various systems and nearly impossible to obtain all kinds of internal and external useful information from huge databases; thus, decision makers cannot develop complete strategic plans. Artificial intelligence (AI) technology extends the boundaries of business practice. Business intelligence systems (BIS) improve their analytical abilities by using corporate information, promote information technology changes by making decisions, and significantly influence business performance by optimizing business decisions and operations [1].

BIS, through continuous management, collect internal and external data on a series of business activities and transform the information, by applying the technologies of

measurement, management, and monitoring. BIS can help to transform the mass data hidden in various departments or operating processes into useful information for the reference of executives at all levels of a company to make decisions rapidly and in real time and thus to carry out preventive management in advance. Moreover, it can help companies to understand customers, grasp business opportunities quickly, maintain rapid and strong decision-making power, set optimal strategic themes and strategic objectives, and create higher profits.

Studies on the adaptation, use, and success of BIS have been greatly developed in the past, creating perfect opportunities for manufacturers to improve their profitability and reduce corporate risks. However, the actual business value of BIS is still very controversial, because it is difficult to integrate BIS into production and manufacturing [2]. Over the past 20 years, BIS has become the basis for corporate decision support, but previous studies show that some large companies have reached a mature stage to introduce BIS. Organizations of all sizes can benefit from using this technology to integrate, manage, and analyze data, which can help them to make decisions and thereby improve their profitability [3]. However, some traditional business organizations are largely unaware of the benefits of BIS and unable to utilize their advantages, so they still hold wait-and-see attitudes toward BIS. In order to accelerate BIS introduction, this study investigated and analyzed the critical factors considered by companies toward BIS.

Most previous studies on critical factors determined the critical factors subjectively [4,5] and not objectively. In addition, the selection of critical factors is also a problem of multi-criteria decision making (MCDM). Therefore, the process of this study is as follows: (1) to collect the three-level hierarchy factors influencing BIS introduction in enterprises from a literature review; (2) to design expert questionnaires of pairwise comparison based on the three-level hierarchy factors; (3) to issue expert questionnaires to senior managers of enterprises that have introduced BIS in Taiwan; (4) to use the fuzzy analytic hierarchy process (FAHP) method to calculate the weights of the factors after the expert questionnaires are returned, and to use the conditions for the acceptable advantage of Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR) to identify the critical factors objectively; (5) to discuss the practical contributions and management implications, to help enterprises to allocate limited resources rationally, introduce BIS efficiently at low costs, and thus raise their decision-making power.

2. Literature Review

This study, through literature collection, mainly calculated factor weights and objectively determined critical factors for companies to introduce BIS by MCDM, which is different from the traditional general methods that need to conduct empirical studies through reasoning. Therefore, this part mainly collected previous literature on the factors to be considered to introduce BIS. The literature is discussed from different perspectives below.

Based on the dynamic capabilities theory and evolutionary theories of organization, Chen and Lin [1] developed the Sense-Transform-Drive (STD) conceptual model of BIS to explain BIS' core capabilities. The results show that BIS-related dynamic capabilities can improve operational efficiency and corporate performance. From the perspective of knowledge conversion, business intelligence has significant influences on the speed of internationalization [6]. Yiu et al. [7] analyzed the financial data of 144 U.S. sample companies that introduced BIS from 2005 to 2014, finding that technology strength and corporate size are important factors for companies to introduce BIS. In addition, with 278 U.S. manufacturing companies using BIS from 2005 to 2014 as research subjects, Yiu et al. [2] pointed out that after the use of BIS, corporate profitability directly improved, and return risks dropped. Moreover, companies with good employee relationships and a high degree of process institutionalization gained obvious competitive advantages from the operation and use of BIS. Hou [8] investigated users' behavioral intention to use BIS by Unified Theory of Acceptance and Use of Technology (UTAUT), showing that performance expectation, social influence, convenience, and computer anxiety are important determinants for users to adopt BIS. In

addition, Rouhani et al. [9] explored the influences of different technical, organizational, and environmental factors on corporate decisions to introduce BIS. Their results indicate that the perceived tangible and intangible benefits, corporate size, organizational readiness, strategies, industrial competition, and competitors' absorption capacities have influences. Zafary [10] investigated 167 companies introducing BIS and considered that organizations should pay more attention to their work procedures to improve the success rate of business intelligence, indicating the importance of work procedure optimization to BIS introduction. Stjepić et al. [11] investigated the risks of introducing BIS in Croatian small- and medium-sized companies by using the technology, organization, and environment (TOE) framework. They found that such companies should consider the internal risks related to organizational dimensions and external risks related to environmental dimensions.

Statistical regression analysis was mainly utilized in the above studies on factors associated with BIS introduction. Some scholars also used tools other than regression analysis to investigate the factors considered by companies to introduce BIS. Eryadi and Hidayanto [12] drew up a questionnaire based on a literature review and interviews with BIS development teams, and 18 experts completed the questionnaire. Their study showed that the most critical factor influencing organizational standards was top management support; the most important factor influencing process standards was effective project management; the most important factors influencing technical standards were system reliability, flexibility, and expandability; and the most important factor influencing environmental standards was supplier selection. In addition, factors related to software tools, suppliers, and opinions influence the process of BIS tool selection [13]. Ahmad et al. [14] conducted 14 semi-structured in-depth interviews with 12 global high-end textile and apparel companies by the qualitative research method, with results revealing that leading BIS solutions could improve value creation processes. El-Adaileh and Foster [15] collected and investigated 38 BIS implementation factors to obtain ten important factors. Some results also prove that the influences of BIS on organizational performance are completely influenced by business process management [16]. Boonsiritomachai et al. [3] proposed a BIS maturity model to investigate small- and medium-sized companies in Thailand. Their results show that the most important factors influencing the BIS level of these companies are comparative advantages, complexity, availability of organizational resources, competitive pressure, supplier selection, and owner–manager innovation.

The majority of previous studies on factors associated with BIS introduction focused on manufacturing-related industries, although some scholars researched industries other than manufacturing. Owusu et al. [17] investigated sample data for 130 bank executives using partial least squares structural equation modeling (PLS-SEM) techniques. Their results show that technical factors (comparative advantages and complexity), organizational factors (advantages and organizational readiness), and environmental factors (regulatory agencies) are the factors motivating Ghanaian banks to introduce BIS. Owusu et al. [18] studied 120 managers and academicians from 12 private universities in Selangor of Malaysia, with results denoting that absorption capacities, competitive pressure, complexity, IT infrastructure, the existence of advantages, senior management support, and supplier selection are the factors that influence BIS introduction by universities.

To help companies to introduce BIS, some scholars proposed the importance of critical factors. Yeoh and Popovič [19] provided evidence to support the concept of critical success factors (CSFs) and demonstrated that BIS stakeholders can fully understand CSFs and the backgrounds influencing the implementation of BIS through a cross-case analysis. Yeoh et al. [20] developed a CSF framework by the Delphi method to investigate critical factors influencing BIS introduction. They found that CSFs are committed to management support and sponsorship, change management oriented to business users, a clear business vision and perfect cases, a business-driven approach and project management, business-focused strengths and balanced project team composition, strategic and extensible technology frameworks, and sustainable data quality and governance frameworks. Mungree et al. [21] considered that the BIS market seems to be developing rapidly, and the importance of

BIS has been widely accepted, but few studies have investigated the CSFs influencing its implementation.

In summary, we found that regression analysis and SEM have been frequently used by authors in previous studies to identify CFs subjectively from influential or important factors involved in the introduction of AI. Although the β value of multiple regression analysis or SEM can be expressed as factor importance, it is an estimate that may be subject to error or collinearity, and its resulting value may even be negative [22]. A better strategy to identify CFs is to use MCDM tools to obtain factor weights and objectively identify CFs.

3. Research Methods

This study mainly collected the factors considered by experts and scholars in studying the introduction of BIS by enterprises. Because there are many factors that companies need to consider, it is necessary to classify, analyze, organize, and give different weights to them. Mastering critical success factors is also a MCDM problem, and among the tools for solving MCDM, AHP [23] is one of the most common. However, the application of AHP fails to consider the fuzziness of human thinking and environmental uncertainty, and, during analysis, the weights determined by decision makers based on the average do not present objective facts. Therefore, van Laarhoved and Pedrycz [24] brought the concept of fuzziness into AHP and then proposed fuzzy AHP (FAHP) to solve the problem in which the fuzziness of human thinking cannot be taken into account in AHP. FAHP considers problem uncertainty, multiple criteria, and the opinions of expert decision makers at the same time, especially when there is a large number of decision criteria and alternatives. FAHP not only avoids the defect of overly subjective pairwise comparison values but also solves inaccurate results. Many scholars now have applied it to solve the problem of MCDM [25,26]. In this study, the weights were calculated by the FAHP and critical factors were determined objectively by using the conditions for the acceptable advantage of Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR). After integrating FAHP and the acceptable advantage of VIKOR, the calculation steps are as follows.

1. Creation of a Hierarchy

The factor hierarchy was established according to the research topic, and the factors in the lower layer can give more precise descriptions of those in the previous layer. Therefore, a factor hierarchy was created.

2. Questionnaire Design

In the questionnaire design, based on the factor hierarchy, the factors on the same layer were compared in pairs to determine their importance. This is the questionnaire obtained by the analytic hierarchy process.

3. Establishment of Fuzzy Numbers

Most previous scholars introduced the discontinuous response method for their questionnaires, while this study adopted the continuous response method. Fuzzy numbers were established based on the response range of all respondents.

4. Establishment of Fuzzy Positive Reciprocal Matrix

The fuzzy numbers obtained from the above questionnaire results were used to establish a fuzzy introspective matrix. When there are sub-criteria to be explored in the same criterion, a fuzzy introspective matrix can be established.

5. Consistency Test

Before weight calculation, the fuzzy weight of the introspective matrix was tested for the consistency index (CI) and consistency ratio (CR)—namely, $CI = (\lambda_{\max} - n)/(n - 1)$ and $CR = (CI/RI_n) \times 100\%$. In this step, the geometric mean was used to define the fuzzy numbers for the consistency test. Saaty [23] suggested that $CI \leq 0.1$ should be the allowable range, where $\lambda_{\max}$ is the maximum eigenvector of the pairwise comparison matrix, n is the

attribute dimension of the matrix, and RI_n is the randomized index [27]. Their values are shown in Table 1.

Table 1. Randomized index of RI_n.

n	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
RI_n	0.525	0.882	1.115	1.252	1.341	1.404	1.452	1.484	1.513	1.535	1.555	1.570	1.583	1.595

6. Establishment of Initial Matrix (matrix)

After a consistency test, an initial matrix was established by using the fuzzy introspective matrix.

7. Defuzzification (α-cut) and Normalization

Defuzzification helps to determine the fuzzy weight according to the α-cut proposed by Csutora and Buckley [28]. The fuzzy weight ranges of all factors were normalized. After the weights of all factors were calculated, the weights were concatenated to obtain the weight of each factor in each layer.

8. Objective Determination of Critical Factors

In this step, the acceptable advantage of VIKOR was adopted to determine critical factors. Let Q (i) be the alternative for the i^{th} evaluation ($i = 1, 2 \ldots j$), j be the number of alternatives, Q (1) be the optimal solution of all alternatives, and Q (2) be the second optimal solution of all alternatives. If TD $\geq DQ$, then the better solution Q (i) is a compromise solution, where DQ = 1/(j − 1) and TD = Q (i +1) − Q (i).

4. Establishment of Hierarchy Table

CFs can therefore help BIS stakeholders to focus on the key points of successful BIS implementations [22]. This study mainly calculated factor weights and determined critical factors by the MCDM method, which is different from the traditional general methods that need to conduct empirical studies through reasoning. Therefore, with the three stages of before, during, and after introduction as a research structure, this plan collected and discussed the literature on critical factors considered by companies to introduce business intelligence systems. It aimed to develop a three-layer factor hierarchy, as shown in Table 2, for questionnaire design and distribution. After questionnaire collection, hybrid MCDM tools were used to objectively determine the critical factors influencing company BIS introduction.

Table 2. The main factor hierarchy and literature for companies to introduce BIS.

Objective Layer	**Target Layer**	**Criterion Layer**	**References**
[10,13] Pre-procurement evaluation	Construction cost	Tangible product cost	[10,16]
		Licensing fee	[10,16]
		Training course fee	[10,16]
	Function	System function integrity	[10,12,13]
		Information technology maturity	[3,7,13]
		Innovation	[3,14]
	Company	Goodwill & brand	[3,12,17]
		Technical capacity	[3,12,13]
		Corporate business structure	[3,12]
Implementation during introduction	Project management	Time management	[12]
		Resource allocation	[10,16]

Table 2. *Cont.*

Objective Layer	Target Layer	Criterion Layer	References
		Change management	[10,12,17,20]
	Integrating capacity	Internal integration	[2,10,11]
		External integration	[11]
		Common design	[16]
	Organizational dimension	Compatibility of technology and culture	[6]
		Commitment and involvement of senior executives	[3,20]
		Cross-functional support and cooperation	[2,16]
Feedback after introduction	Operation cost	System maintenance cost	[2,10,19]
		Software upgrade cost	[2,10,19]
		Operating cost	[2,10,19]
	Benefit realization	Approaching corporate strategy	[15,21]
		Enhancing corporate competitiveness	[1,2,9]
		Decision quality	[20]
	Educational training and technical support	User training	[8,16]
		Main window resource	[12,20]
		Application engineer involvement	[8,16]

5. Data Collection

This study explored the critical factors considered by companies in intruducing and using BIS. Data collection and result analysis are described as follows.

This study applied weight analysis on the influencing factors highlighted by individuals in Taiwanese companies who had participated in the BIS introduction to help to understand the factors. This study mainly focuses on the factors influencing BIS introduction, and so the questionnaires needed to be answered by individuals who had participated in BIS introduction. Because FAHP is a method to collect expert opinions rather than a statistical method, the more senior experts there are to respond to the questionnaire, the better the results obtained. Hence, purposive sampling was adopted in this study. Purposive sampling is a non-probabilistic sampling method adopted when factors are selected by the judgment of researchers. Researchers generally agree that it may save time and costs to obtain representative samples through sound judgments [29]. Regarding the sample size of the expert questionnaires, Delbecq et al. [30] claimed that 15 to 30 is a reasonable sample if the group of experts is highly homogeneous.

(1) Questionnaire Design

This study used the FAHP method for data analysis. Therefore, in the questionnaire design, pairwise comparison was adopted for respondents to complete their questionnaires. The response range was between 1 and 9, so that respondents could answer their questionnaires by marking, and the marking range was not restricted. Regarding the questionnair design of this study, for example, the three factors before and during the introduction on the target layer, as shown in Table 3, were answered by marking to avoid any impatience caused by too many questions.

Table 3. Pairwise independence questionnaire.

Importance Level	Absolutely Important		Very Strongly Important		Essentially Important		Weekly Important		Equally Important		Weekly Important		Essentially Important		VeryStrongest Important		Absolutely Important		Importance Level
	←								●									→	
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
Construction cost																			Function
Construction cost																			Company
Function																			Company

(2) Questionnaire Collection and Weight Calculation

This study developed the factor sheet in Table 2 into an expert questionnaire for pairwise comparison, which was mainly distributed to experts who had actually participated in BIS introduction. Their average length of service was 9.5 years. In total, 45 questionnaires were distributed, and 22 were collected. The answers from experts who had actually participated in the BIS introduction and had professional knowledge could represent companies' attitudes towards BIS introduction and could ensure that the results are closer to the actual situation, thus meeting the requirements of purposive sampling. In the end, after questionnaire collection, it was necessary that all questionnaires were tested for consistency, and then the weights of all factors were calculated by FAHP (as shown in Table 4).

Table 4. Weights of factors influencing companies to introduce business intelligence.

A Objective Layer, Initial Weight [Rank]	B Target Layer, Initial Weight [Rank]	C = A × B Target Layer, Weights after Concatenation [Rank]	D Criterion Layer	D Criterion Layer, Initial Weight [Rank]	E = C × D Criterion Layer, Weights after Concatenation [Rank]
Pre-procurement 0.6112	Construction cost 0.2356 [2]	0.1440 [3]	Tangible product cost	0.2416	0.034790
			Licensing fee	0.6528	0.094003
			Training course fee	0.1057	0.015221
	Function 0.6592 [1]	0.4029 [1]	System function integrity	0.6837	0.275463
			Information technology maturity	0.2186	0.088074
			Innovation	0.0976	0.039323
	Company 0.1052 [3]	0.0642 [5]	Goodwill & brand	0.2549	0.016365
			Technical capacity	0.6520	0.041858
			Corporate business structure	0.0932	0.005983
During introduction 0.1014	Project management 0.0898 [3]	0.0091 [9]	Time management	0.1046	0.000952
			Resource allocation	0.2526	0.002299
			Change Management	0.6428	0.005849
	Integrating capacity 0.6360 [1]	0.0645 [4]	Internal integration	0.6442	0.041551
			External integration	0.2327	0.015009
			Common design	0.1231	0.007940
	Organizational dimension 0.2742	0.0278	Compatibility of technology and culture	0.1054	0.002930
			Commitment and involvement of senior executives	0.6594	0.018331
			Cross-functional support and cooperation	0.2352	0.006539

Table 4. *Cont.*

A Objective Layer, Initial Weight [Rank]	B Target Layer, Initial Weight [Rank]	C = A × B Target Layer, Weights after Concatenation [Rank]	D Criterion Layer	D Criterion Layer, Initial Weight [Rank]	E = C × D Criterion Layer, Weights after Concatenation [Rank]
After introduction 0.2874	Operation cost 0.0827	0.0238	System maintenance cost	0.6645	0.015815
			Software upgrade cost	0.2237	0.005324
			Operating cost	0.1118	0.002661
	Benefit realization 0.6992	0.2010	Approaching corporate strategy	0.6243	0.125484
			Enhancing corporate competitiveness	0.2494	0.050129
			Decision quality	0.1263	0.025386
	Educational training and technical support 0.2181	0.0627	User training	0.2721	0.017061
			Main window resource	0.0976	0.006120
			Application engineer involvement	0.6303	0.039520

(3) CF Extraction

In order to avoid recognizing too many options in the initial steps, the first 9 most important factors with a cumulative weight of 79.54% (80/20 rule) were selected for CF recognition, while the other 18 were defined as secondary important factors. Break values were first determined by the following equation: Break value (i) = (Qi − Qj)/(Q1 − Q14). For example, break value (2) = (0.275463 − 0.125484)/(0.275463 − 0.0239323) = 0.63 51. Through this program, the break values of all 9 factors were obtained (Table 5).

This study utilized the acceptable advantage of VIKOR to gradually recognize a set of feasible solutions and to recognize the optimal set of alternatives from multiple alternatives. They were then used for CF recognition in an objective manner. Most studies on CF examination showed that there were four to six CFs [4,31–33]. Therefore, CF extraction was the extraction principle of this study. It was stopped immediately until at least four CFs were recognized with cumulative weights exceeding 50% [34,35]. Based on this extraction principle, two factors indicated TD ≥ DQ in the first extraction. Two CFs with a cumulative weight of 40.09% (<50%) were extracted. As the results of the first extraction failed to meet the conditions for stopping, the second extraction was carried out. No CF was extracted in the second extraction, indicating that the third and fourth factors were almost equally important. In other words, in the next extraction, if TD ≥ DQ for the fourth factor, then the third and fourth factors must be extracted together. The third extraction was then carried out once again, and the results showed TD ≥ DQ for the fourth factor. Therefore, the third and fourth factors were extracted together, and four CFs in total were extracted, with a cumulative weight of 58.30%. The extraction was stopped according to the extraction principle. Through three extractions, four CFs were obtained: system function integrity, approaching corporate strategy, licensing fee, and information technology maturity (Table 5).

Table 5. CFs' extraction for influencing MRs in introducing MP tools.

	1st Extraction					2nd Extraction					3rd Extraction				
Factors	**Weight**	**Rank (*n*)**	**Break Value**	**TD**	**TD ≥ DQ**	**Weight**	**Rank (*n*)**	**Break Value**	**TD**	**TD ≥ DQ**	**Weight**	**Rank (*n*)**	**Break Value**	**TD**	**TD ≥ DQ**
System function integrity	0.275463	1	0.0000	0.6351	Yes										
Approaching corporate strategy	0.125484	2	0.6351	0.1333	Yes										
Licensing fee	0.094003	3	0.7684	0.0251	No	0.094003	1	0.0000	0.1084	No					Yes
Information technology maturity	0.088074	4	0.7936	0.1607		0.088074	2	0.1084	0.6939		0.088074	1	0.0000	0.7783	Yes
Enhancing corporate competitiveness	0.050129	5	0.9542	0.0350		0.050129	3	0.8024	0.1513		0.050129	2	0.7783	0.1697	No
Technical capacity	0.041858	6	0.9893	0.0013		0.041858	4	0.9536	0.0056		0.041858	3	0.9480	0.0063	
Internal integration	0.041551	7	0.9906	0.0086		0.041551	5	0.9593	0.0371		0.041551	4	0.9543	0.0417	
Application engineer involvement	0.03952	8	0.9992	0.0008		0.03952	6	0.9964	0.0036		0.03952	5	0.9960	0.0040	
Innovation	0.039323	9	1.0000			0.039323	7	1.0000			0.039323	6	1.0000		
	DQ = 1/8 = 0.125					DQ = 1/6 = 0.1667					DQ = 1/5 = 0.2				

6. Result Analysis

The 4 CFs obtained by the above method through three extractions were system function integrity, approaching corporate strategy, licensing fee, and information technology maturity, along with 5 important factors and 18 secondary important factors. Critical factors and practical contributions were analyzed as follows.

6.1. Critical Factor Analysis

(1) System function integrity: business intelligence is often used for modularizing corporate problems and analyzing business data based on multiple dimensions, such as time, region, organization, or a product structure tree, to support organizational decisions. Therefore, companies attach great importance to system function integrity in introducing BIS, because incomplete systems will disconnect operations, influence business operations, and reduce user confidence in participation.

(2) Approaching corporate strategy: the most anticipated benefit of BIS is that the performance in corporate competitiveness and decision quality is recognized by decision makers. In the decision-making process, the development goal of each information system is to provide the right information to the right user at the right time. The main performance of users in introducing BIS depends on whether it meets companies' strategic needs.

(3) Licensing fee: BIS tools that use open-source codes can often customize their functions to meet the needs of small organizations in data mining and reporting. For large companies, these plans may not be flexible enough to meet their needs. In contrast, commercial BIS require various resources and support, as well as fully integrated enterprise-level regulation capabilities. Since subsequent tangible product costs or training course fees are packaged into licensing fees, large companies consider the influence of BIS licensing fees to be significant.

(4) Information technology maturity: in order to assist in decision making, business intelligence reports must meet the requirement of random data analysis and be able to predict future trends based on the existing data. Its technical requirements for users are low, but multiple data processing and access technologies must be applied. Its architecture is complex and requires high information technology maturity in companies, and the system construction standard is high. Therefore, characteristics of BIS, such as functional integrity and technical maturity, will become the main factors to be considered for introduction.

6.2. Research Contributions

(1) FAHP was adopted as the method in this study. This method is somewhat subjective in collecting factors based on expert opinions but can simplify the importance and weight ranking of influencing factors considered by users. Moreover, many scholars have demonstrated that FAHP is a suitable method for making selections.

(2) From the perspective of marketing, this study set the three stages of BIS introduction (pre-procurement, during, and after introduction) as stratified objectives, which could serve as a reference for BIS suppliers in product and service marketing. The surveyed experts in this study had actual experience in AI introduction, and the research results are of practical reference value.

(3) This study divided the factors influencing BIS introduction into four critical factors, five important factors, and eighteen secondary important factors. Companies that intend to introduce BIS can allocate major resources to critical factors. If there are resources remaining, then they can allocate them to important factors. If there are still resources remaining, then they can allocate them according to the weights of secondary important factors. For companies that have not yet introduced BIS, the results can be used as a reference for effective resource allocation in future BIS introduction evaluations.

6.3. Management Implications

(1) Providing comprehensive factors: Previous studies were limited by theoretical models and could not explore multiple factors simultaneously. In this study, using a hierar-

chical framework, 27 influencing factors were collected from various theories and models. Therefore, CFs could be more fully identified from a wider range of factors.

(2) Better resource allocation: Compared with previous studies that only put forward CFs, the results of this study are more useful for assisting companies that want to introduce BIS, because each CF found in this study has a weight and can be allocated optimal introduction resources.

(3) Improved success rate of BIS introduction: The factors collected in this study are more comprehensive. Under limited resources, introducing BIS according to the CFs found by experts can reduce the risk of introduction failure.

7. Conclusions

The main advantage of BIS is its ability to systematically extract and collect data from existing forms of data sources (perhaps from multiple heterogeneous data sources) to eliminate poor data and retain correct and decision-related data, for the reference of decision makers in analysis and application. The most important factors behind companies' adoption of BIS are the ability to grasp market opportunities more quickly than their competitors, perform rapid and correct decision analyses, reduce the information gap caused by human factors, enhance competitiveness, and achieve business objectives.

Most previous studies on BIS introduction determined significant or relevant factors by statistical regression analysis, and then the authors made subjective judgments on critical factors, thus lacking objectivity. In order to accelerate BIS introduction, this study integrated two MCDM tools to determine critical factors objectively. First, the factors considered by companies to introduce BIS were collected from the literature and developed into a three-layer factor hierarchy according to the three stages of before, during, and after introduction in marketing that organizations undergo during the procurement process. Second, an expert questionnaire was designed to compare factors in pairs according to the sheet and sent to senior executives in companies that have introduced BIS, and the weights of all factors were calculated by FAHP based on the collected questionnaire data. Third, four critical factors—system function integrity, approaching corporate strategy, licensing fee, and information technology maturity—were determined by using the acceptable advantage of VIKOR and further explored, to help companies input fewer resources, introduce BIS efficiently, and thus raise their decision-making power.

This study only took large corporate information executives in Taiwan as the expert subjects. It is suggested that future studies can try to include end users who have extensive experience or understanding of BIS as expert subjects so as to fully expose the importance and relative benefits of BIS in corporate procurement. In addition, this study was carried out in Taiwan. In the future, the authors could investigate intermittent issues and conduct comparative analyses across different industries, different business scales, or different areas to identify differences.

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References

1. Chen, Y.S.; Lin, Z.J. Business Intelligence Capabilities and Firm Performance: A Study in China. *Int. J. Inf. Manag.* **2020**, *57*, 102232. [CrossRef]
2. Yiu, L.M.D.; Yeung, A.C.L.; Cheng, T.C.E. The impact of business intelligence systems on profitability and risks of firms. *Int. J. Prod. Res.* **2020**, *59*, 3951–3974. [CrossRef]
3. Boonsiritomachai, W.; McGrath, G.M.; Burgess, S.; Liu, S.F. Exploring business intelligence and its depth of maturity in Thai SMEs. *Cogent Bus. Manag.* **2016**, *3*, 1220663. [CrossRef]
4. Hu, K.-H.; Chen, F.-H.; Hsu, M.-F.; Yao, S.; Hung, M.-C. Identification of the Critical Factors for Global Supply Chain Management under the COVID-19 Outbreak via a Fusion Intelligent Decision Support System. *Axioms* **2021**, *10*, 61. [CrossRef]
5. Huang, S.-W.; Liou, J.J.H.; Cheng, S.-H.; Tang, W.; Ma, J.C.Y.; Tzeng, G.-H. The Key Success Factors for Attracting Foreign Investment in the Post-Epidemic Era. *Axioms* **2021**, *10*, 140. [CrossRef]
6. Cheng, C.; Zhong, H.H.; Cao, L.B. Facilitating speed of internationalization: The roles of business intelligence and organizational agility. *J. Bus. Res.* **2020**, *110*, 95–103. [CrossRef]
7. Yiu, L.M.D.; Yeung, A.C.L.; Jong, A.P.L. Business intelligence systems and operational capability: An empirical analysis of high-tech sectors. *Ind. Manag. Data Syst.* **2020**, *120*, 1195–1215. [CrossRef]
8. Hou, C.K. Exploring the user acceptance of business intelligence systems in Taiwan's electronics industry: Applying the UTAUT model. *Int. J. Internet Enterp. Manag.* **2014**, *8*, 195. [CrossRef]
9. Rouhani, S.; Ashrafi, A.; Ravasan, A.Z.; Afshari, S. Business Intelligence Systems Adoption Model: An Empirical Investigation. *J. Organ. End User Compu.* **2018**, *30*, 43–70. [CrossRef]
10. Zafary, F. Implementation of business intelligence considering the role of information systems integration and enterprise resource planning. *J. Intell. Stud. Bus.* **2020**, *1*, 59–74. [CrossRef]
11. Stjepić, A.-M.; Bach, M.P.; Vukšić, V.B. Exploring Risks in the Adoption of Business Intelligence in SMEs Using the TOE Framework. *J. Risk Financ. Manag.* **2021**, *14*, 58. [CrossRef]
12. Eryadi, R.A.; Hidayanto, A.Z. Critical Success Factors for Business Intelligence Implementation in an Enterprise Resource Planning System Environment Using DEMATEL: A Case Study at a Cement Manufacture Company in Indonesia. *J. Inf. Technol. Manag.* **2020**, *12*, 67–85.
13. Gina, B.; Budree, A.A. Review of Literature on Critical Factors that Drive the Selection of Business Intelligence Tools. In Proceedings of the IEEE International Conference on Advances in Big Data, Computing and Data Communication Systems (icABCD), Durban, South Africa, 6–7 August 2020; pp. 1–7.
14. Ahmad, S.; Miskon, S.; Alabdan, R.; Tlili, I. Towards Sustainable Textile and Apparel Industry: Exploring the Role of Business Intelligence Systems in the Era of Industry 4.0. *Sustainability* **2020**, *12*, 2632. [CrossRef]
15. El-Adaileh, N.A.; Foster, S. Successful business intelligence implementation: A systematic literature review. *J. Work. Manag.* **2019**, *11*, 121–132. [CrossRef]
16. Dalia, S.V.; Vesna, B.V.; Mirjana, P.B.; Jurij, J.; Mojca, I.S. Business intelligence and organizational performance: The role of alignment with business process management. *Bus. Process Manag. J.* **2020**, *26*, 1709–1730.
17. Owusu, A.; Aha, G.C.A.; Bakare, T.A.; Soladoye, A. Determinants of Business Intelligence Systems Adoption in Developing Countries: An Empirical Analysis from Ghanaian Banks. *J. Int. Bank. Commer.* **2017**, *22*, S8.
18. Owusu, A.; Ghanbari-Baghestan, A.; Kalantari, A. Investigating the Factors Affecting Business Intelligence Systems Adoption: A Case Study of Private Universities in Malaysia. *Int. J. Technol. Diffus.* **2017**, *8*, 25. [CrossRef]
19. Yeoh, W.; Popovič, A. Extending the understanding of critical success factors for implementing business intelligence systems. *J. Assoc. Inf. Sci. Technol.* **2015**, *67*, 134–147. [CrossRef]
20. Yeoh, W.; Koronios, A.; Gao, J. Managing the Implementation of Business Intelligence Systems: A Critical Success Factors Framework. *Int. J. Enterp. Inf. Syst.* **2008**, *4*, 79–84. [CrossRef]
21. Mungree, D.; Rudra, A.; Morien, D. A Framework for Understanding the Critical Success Factors of Enterprise Business Intelligence Implementation. In Proceedings of the Nineteenth Americas Conference on Information Systems, Chicago, IL, USA, 15–17 August 2013.
22. Hair, J.F.; Black, W.C.; Babin, B.J. *Multivariate Data Analysis: Global Edition*; Pearson Education: London, UK, 2010.
23. Saaty, T.L. *The Analytic Hierarchy Process*; McGraw-Hill: New York, NY, USA, 1980.
24. van Laarhoven, P.J.M.; Pedrycz, W. A fuzzy extension of Satty's priority theory. *Fuzzy Sets Syst.* **1983**, *11*, 229–241. [CrossRef]
25. Wu, C.K.; Wang, C.-N.; Le, T.K.T. Fuzzy Multi Criteria Decision Making Model for Agritourism Location Selection: A Case Study in Vietnam. *Axioms* **2022**, *11*, 176. [CrossRef]
26. Thanh, N.V.; Lan, N.T.K. A New Hybrid Triple Bottom Line Metrics and Fuzzy MCDM Model: Sustainable Supplier Selection in the Food-Processing Industry. *Axioms* **2022**, *11*, 57. [CrossRef]
27. Aguaron, J.; Moreno-Jimenez, J.M. The geometric consistency index: Approximated thresholds. *Eur. J. Op. Res.* **2003**, *147*, 137–145. [CrossRef]
28. Csutora, R.; Buckley, J.J. Fuzzy hierarchical analysis: The Lambda-Max method. *Fuzzy Sets Syst.* **2001**, *120*, 181–195. [CrossRef]
29. Black, K. *Business Statistics: Contemporary Decision Making*, 6th ed.; John Wiley & Sons: New York, NY, USA, 2010.
30. Delbecq, A.L.; Van de Ven, A.H.; Gustafson, D.H. *Group Techniques for Program Planning: A Guide to Nominal Group and Delphi Processes*; Scott Foresman: Northbrook, IL, USA, 1975.

31. Chirapanda, S. Identification of success factors for sustainability in family businesses: Case study method and exploratory research in Japan. *J. Fam. Bus. Manag.* **2020**, *10*, 58–75. [CrossRef]
32. Janjić, V.; Todorović, M.; Jovanović, D. Key Success Factors and Benefits of Kaizen Implementation. *Eng. Manag. J.* **2019**, *32*, 98–106. [CrossRef]
33. Moya, S.; Camacho, M. Identifying the key success factors for the adoption of mobile learning. *Educ. Inf. Technol.* **2021**, *26*, 3917–3945. [CrossRef]
34. Fu, H.-P.; Yeh, H.; Ma, R.-L. A study of the CSFs of an e-cluster platform adoption for microenterprises. *Inf. Technol. Manag.* **2017**, *19*, 231–243. [CrossRef]
35. Hsu, K.Y.; Fu, H.P.; Lin, A.J.; Ou, T.Y. Factor analysis of SMEs entering foreign markets: The case of Taiwanese SMEs in Vietnam. *Eur. J. Int. Manag.* **2020**, *14*, 524. [CrossRef]