Feasibility of implementing B2B e-commerce in small and medium enterprises

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Abstract: - E-commerce has substantially affected the business world in the recent, and its importance is expected to continue increasing in future. Since implementing B2B e-commerce in small and medium enterprises (SMEs) is a long-term commitment and such enterprises are more limited in terms of resources than large enterprises, the predicted value of successful implementation is extremely useful in deciding whether to initiate B2B e-commerce. This investigation establishes an analytical hierarchy framework to help SMEs predicting implementation success as well as identifying the actions necessary before implementing B2B e-commerce to increase e-commerce initiative feasibility. The consistent fuzzy preference relation is used to improve decision making consistency and effectiveness. A case study involving six influences solicited from a Taiwanese steel company is used to illustrate the feasibility and effectiveness of the proposed approach.

Key-Words: - B2B e-commerce; small and medium enterprises; multi-criteria decision making; consistent fuzzy preference relation

1 Introduction

The Internet is changing business operating practices. The accelerated development of modern communications technology, coupled with the growing penetration rate of the Internet, has fueled e-commerce growth. E-commerce has been proposed to have a major impact in terms of threats and opportunities for intermediaries in many industries.

E-commerce has substantially affected the business world in the recent, and its importance is expected to continue increasing in future. The term ‘‘e-commerce’’ emerged only in recent years as businesses became aware of the potential role of the Internet as a powerful medium for conducting business. In the past decade, e-commerce has substantially affected the business world and is expected to increase in importance. The benefits of e-commerce are apparent not only for large firms but also for small and medium enterprises (SMEs) [8]. However, some governments have noted the relatively slow uptake of electronic commerce in the SME sector [2, 7]. Deciding whether to implement B2B is difficult in many organizations and particularly in SMEs. This vital decision may promote growth in an organization or lead to its downfall; consequently, all aspects of implementation must be considered before reaching a consensus within an organization.

Despite numerous reports of successful B2B e-commerce implementation, several examples of failure have also occurred around the world. Implementing B2B e-commerce is time consuming, and the long-term impact on an organization may take time to become clear. Since implementing B2B e-commerce in SMEs is a long-term commitment requiring substantial resources, the predicted value of successful implementation is required for decision-making regarding whether to initiate B2B e-commerce. The feasibility of implementation and an effective decision making approach thus can facilitate B2B e-commerce implementation in SMEs. Additionally, although previous studies of e-commerce adoption have examined user acceptance, consumer behaviour, e-commerce software, investment decision making factors in adopting e-commerce, selection of e-commerce sites by the consumer, the impact of innovation and pricing strategies [1, 3, 6, 10, 14, 15, 16, 17, 18, 21, 23, 24, 25], few studies have investigated the magnitude of all these factors on B2B e-commerce implementation in SMEs. Thus, elucidating the factors required for successful electronic commerce, particularly in the SME sector, is a worthwhile endeavor.

The focus on B2B e-commerce in SMEs has become an increasingly important topic for both researchers and SME managers. The proposed prediction model based on the reciprocal additive consistent fuzzy preference relation [9] in this study can help organizations identify key factors affecting B2B e-commerce implementation in SMEs and remedial action necessary to ensure successful implementation.

The rest of this paper is organized as follows. The following section discusses the reciprocal additive consistent fuzzy preference relation. Section 3 then presents an analytical hierarchy framework based on additive reciprocity transitivity for predicting B2B e-commerce implementation in SMEs. Next, Section 4 introduces an empirical case study of B2B e-commerce implementation in Taiwan SMEs. Finally, a discussion and conclusions are presented in Section 5.

2 Reciprocal Additive Consistent Fuzzy Preference Relation

Numerous factors determine the success of B2B e-commerce implementation in SMEs. Essential considerations include not only financial issues but also organizational culture, government policies, industry characteristics and so on [5, 8, 11, 13, 19, 26, 27, 28]. In SMEs, enormous care is necessary in implementing B2B e-commerce systems. Considerations include enterprise internal, external qualitative and quantitative attributes. The numerous considerations suggest the need for an analytical hierarchy to properly address the issue [12]. A well-known approach for effectively addressing this problem is the Analytic Hierarchy Process (AHP) proposed by Saaty [22]. The AHP methodology separates a complex decision issue into elemental problems to establish a hierarchical model. When the decision problem is hierarchically divided into smaller constituent parts, the relative importance of elements are compared pairwise at each level to establish a set of priorities. Although AHP is widely employed in diverse fields [4, 20], inconsistency increases as hierarchies of criteria or alternatives increase [30]. To address this dilemma, Herrera-Viedma et al. [9] presented a set of consistent fuzzy preference relations to facilitate the effectiveness and accuracy of decision-making. Each of these preference relations requires completion of all $\frac{n(n-1)}{2}$ judgments to produce a preference matrix containing n elements. To reduce judgment time, this study employs the reciprocal additive consistent fuzzy preference relation proposed by Herrera-Viedmas et al. [9] as the basis for predicting the success of B2B e-commerce implementation in SMEs because it only requires $n-1$ judgments from a set of n elements.

Herrera-Viedma et al. proposed consistent fuzzy preference relations in accordance with two preference relations, namely multiplicative preference relation and fuzzy preference relation [29]. This study is based on the methodology of consistent fuzzy preference relations, which is presented below:

(1) Multiplicative preference relation. Experts express preferences regarding a set of alternatives since X can be denoted by a preference relation matrix $A \subset X \times X$, $A=(a_{ij}), a_{ij} \in \left[\frac{1}{9}, 9\right]$, where a_{ij} denotes the ratio of the preference degree of alternative x_i over x_j . As $a_{ij}=1$ indicates no difference between x_i and x_j, $a_{ij}=9$ indicates that x_i is highly preferable to x_j. A is assumed to be a multiplicative reciprocal, that is

$$a_{ij} \cdot a_{ji} = 1 \tag{1}$$

(2) Fuzzy preference relation. Experts express preferences over a set of alternatives where X is denoted by a positive preference relation matrix $P \subset X \times X$ with membership function: $\mu_p : X \times X \to [0,\ 1]$, where $\mu_p(x_i, x_j) = p_{ij}$ indicates the ratio of the preference intensity of alternative x_i to that of x_j. Moreover, if $p_{ij}=\frac{1}{2}$ implies indifference between x_i and x_j ($x_i \sim x_j$), $p_{ij}=1$ indicates that x_i is absolutely preferred to x_j , $p_{ij}=0$ indicates x_j is absolutely preferred to x_i, and $p_{ij} > \frac{1}{2}$ indicates that x_i is preferred to x_j ($x_i \succ x_j$). Meanwhile, P is assumed to be an additive reciprocal, given by

$$p_{ij} + p_{ji} = 1 \tag{2}$$

Proposition 1 Reciprocal additive fuzzy preference relation

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

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \quad \forall i < j < k \tag{4}$$

$$p_{i(i+1)} + p_{(i+1)(i+2)} + \dots + p_{(j-1)j} + p_{ji} = \frac{j-i+1}{2} \quad \forall i < j \tag{5}$$

Proposition 2 Assuming a set of alternatives $X = \{x_1, x_2, \cdots, x_n\}$, which is associated with a multiplicative preference relation $A = (a_{ij}), a_{ij} \in [\frac{1}{9}, 9]$, then the corresponding reciprocal additive fuzzy preference relation $P = (p_{ij})$ with $p_{ij} \in [0,1]$ to $A = (a_{ij})$ is defined as follows.

$$p_{ij} = g(a_{ij}) = \frac{1}{2}(1 + \log_9 a_{ij}) \quad (6)$$

Using the transformation function $g(a_{ij})$, a multiplicative preference relation matrix can be transformed into various preference relations.

Notably, according to Proposition 1, only $n-1$ ($\{p_{12}, p_{23}, ..., p_{n-1n}\}$) judgements are required to construct consistent fuzzy preference relations. The other incomplete elements can be constructed by additive transitivity. If the preference matrix contains values that are not in the interval $[0, 1]$ but rather are in $[-a, 1+a]$, a linear transformation is required to preserve the reciprocity and additive transitivity, that is, $f : [-a, 1+a] \to [0, 1]$. For further detail see Herrera-Viedma et al. [9].

3 Framework for Accurately Predicting the Success of B2B E-commerce Implementation in SMEs

3.1 Influential factors and framework of the prediction model

Figure 1 shows the hierarchical structure for addressing the problem of forecasting the success of B2B e-commerce implementation in SMEs. The influential factors are synthesized from the reviewed literature [5, 8, 11, 13, 19, 26, 27, 28] as well as consultations with and guidance from several experts, including two professors in information management, one professor in information engineering, three professors in business administration and three experienced B2B e-commerce project managers. The criteria and their attributes are summarized as follows:

- Management support (C_1). Top management support and functional management support.
- Firm size (C_2).Capital, employees, turnover and other attributes of a company.
- IT integration (C_3).Sophistication and integration of IT.
- Organizational culture (C_4).Willingness to change and commit substantial resources.
- Government policies (C_5).Policies for allocating financial or technological resources to B2B.
- Industry characteristics (C_6).Multinational companies and trendsetting companies.

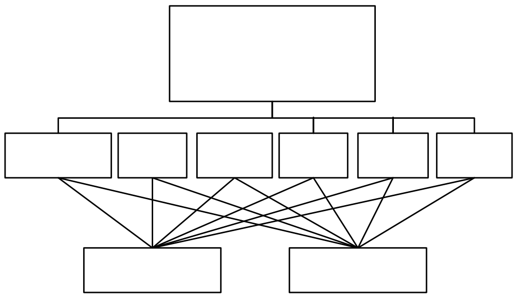

Fig. 1. The analytical framework

3.2 Hierarchical analytical process for predicting outcomes

3.2.1 Linguistic variables

Pairs of factors were compared using expressions such as “equally important” (EQ), “slightly more important” (WK), “strongly more important” (ST), “extremely strongly more important” (VS), and “absolutely more important” (AB), using a five level scale with values indicated by actual numbers (see Table 1).

Table 1. Linguistic terms for priority weights

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

Additionally, three linguistic variables, namely, “very high” (VH), “high” (H), and “fair” (F), were used to measure the success of B2B e-commerce implementation in SMEs (see Table 2).

Table 2. Linguistic variables for probable outcomes of e-commerce implementation

Definition	Intensity of importance
Fair (F)	1
High (H)	3
Very high (VH)	5
Intermediate values used to present compromise	2,4

3.2.2 Prioritizing the influential factors

The procedures for the reciprocal additive consistent fuzzy preference relation for prioritizing influential factors are given below.

(1) Establish pairwise comparison matrices among all factors $(C_i,\ i=1,2,...,n)$ in the dimensions of the hierarchy system. The evaluators $(E_k,\ k=1,2,...,m)$ provide the more important of each pair of influential factors for a set of $n-1$ preference values $(a_{12}, a_{23}, ..., a_{(n-1)n})$, for example:

$$A^k = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} 1 & a_{12}^k & x & x \\ x & 1 & a_{23}^k & x \\ \vdots & \vdots & \vdots & \vdots \\ x & x & \cdots & 1 \end{bmatrix} \end{array}$$

Where a_{ij}^k denotes the preference intensity toward influential factors i and j assessed by evaluator. The sign "x" indicates the remaining a_{ij}^k, which can be derived via inverse comparison.

(2) Transform the preference value a_{ij}^k into p_{ij}^k using an interval scale [0, 1], then derive the remaining p_{ij}^k based on the reciprocal transitivity property as follows

$$P^k = \frac{1}{2}(1+\log_9 A^k) = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} 0.5 & p_{12}^k & x & x \\ x & 0.5 & p_{23}^k & x \\ \vdots & \vdots & \vdots & \vdots \\ x & x & \cdots & 0.5 \end{bmatrix} \end{array}$$

where $p_{ij} = 0.5$ indicates no difference between factors i and j. The remaining p_{ij}^k can be calculated using Eqs (2) and (5). However, in an interval $[-a,\ 1+a]$, a transformation function is required to preserve the reciprocity and additive transitivity. The transformation function is

$$f(p_{ij}^k) = (p_{ij}^k + a)/(1+2a) \tag{7}$$

where a denotes the absolute value of the minimum negative value in this preference matrix.

(3) Pull the opinions of evaluators to obtain the aggregated weights of the factor. This study uses the average value to integrate the judgment values of m evaluators, namely

$$p_{ij} = (p_{ij}^1 + p_{ij}^2 + ... p_{ij}^m)/m \tag{8}$$

(4) The aggregated fuzzy preference relation matrices r_{ij} are normalized to indicate the normalized fuzzy preference values of each influential factor, such as

$$r_{ij} = p_{ij} \Big/ \sum_{i=1}^{n} p_{ij} \tag{9}$$

(5) Using the w_i denoting the average priority weight of influential factor i, the priority of each factor can be obtained, that is

$$w_i = \frac{1}{n}\sum_{j=1}^{n} r_{ij} \tag{10}$$

3.2.3 Obtaining the synthetic utility value with each factor

The evaluators were asked to express their subjective judgments regarding the preference ratings of probable outcomes of B2B e-commerce implantation for SMEs ($A_u,\ u=1,2,...,s$), $s=2\ (S: success, F: failure)$, with respect to each influential factor in linguistic terms.

(1) For each influential factor, the evaluators were requested to evaluate the probabilities of two outcomes for a set of $s-1$ preference data $(g_{12}, g_{23}, ..., g_{(s-1)s})$, for example

$${}_iG = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_s \end{array} \begin{array}{c} \begin{array}{cccc} A_1 & A_2 & \cdots & A_s \end{array} \\ \begin{bmatrix} 1 & {}_ig_{12}^k & x & x \\ x & 1 & {}_ig_{23}^k & x \\ \vdots & \vdots & \vdots & {}_ig_{(s-1)s}^k \\ x & x & \cdots & 1 \end{bmatrix} \end{array}$$

where ${}_i g_{uv}^k$ represents the performance value assigned by evaluator k to probable outcomes u and v based on influential factor i.

(2) Next, the preference value ${}_i g_{uv}^k$ is transformed within the range $[\frac{1}{5},\ 5]$ into ${}_i q_{uv}^k$ in an interval scale [0, 1], and the remaining ${}_i q_{uv}^k$ are obtained via the reciprocal transitivity property as follows

$$
{}_iQ = \frac{1}{2}(1+\log_5 {}_iG) = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_s \end{array} \begin{array}{c} \begin{array}{cccc} A_1 & A_2 & \cdots & A_s \end{array} \\ \begin{bmatrix} 0.5 & {}_iq_{12}^k & x & x \\ x & 0.5 & {}_iq_{23}^k & x \\ \vdots & \vdots & \vdots & {}_iq_{(s-1)s}^k \\ x & x & \cdots & 0.5 \end{bmatrix} \end{array}
$$

(3) The opinions of evaluators are then taken to obtain the transformed synthetic rating of the probable outcome for each influential factor ${}_i q_{uv}^k$ which denotes the transformed fuzzy preference value of evaluator k for assessing probable outcomes u and v in terms of influential factor i. This study using the notation of the average value, this study integrates the judgment values of m evaluators; that is

$$
{}_i q_{uv} = \frac{1}{m}\sum_{j=1}^{m} {}_i q_{uv}^m \tag{11}
$$

(4) After normalizing the synthetic fuzzy preference rating of the probable outcomes for each influential factor, ${}_i\gamma_{uv}$ is adopted to indicate the normalized rating of probable outcomes u and v with respect to influential factor i, for example

$$
{}_i\gamma_{uv} = {}_i q_{uv} \Big/ \sum_{u=1}^{s} {}_i q_{uv} \tag{12}
$$

(5) Consequently, ${}_i\bar{\eta}_u$ denotes the average rating of probable outcome u with respect to influential factor i. The desired rating of each probable outcome can be derived for each influential factor, that is,

$$
{}_i\bar{\eta}_u = \frac{1}{s}\sum_{v=1}^{s} \gamma_{uv} \tag{13}
$$

3.2.4 Obtaining the priority weight for probable outcomes

A preferred value R_u for the company is obtained by multiplying the priority weights of influential factors by the ratings of probable outcomes. That is,

$$
R_u = \sum_{i=1}^{n} {}_i\bar{\eta}_u\, w_i \tag{14}
$$

4 Empirical Case for Proposed Model

This study examined a Taiwan steel company as an example to demonstrate the analytical framework. Twelve questionnaires were dispatched to survey candidates to analyze the probability of successful B2B e-commerce implementation.

4.1 Weighting calculation of influential factors

Six major factors were considered in predicting the success of B2B e-commerce implementation considered here. The following examples clarify the computational process used to derive the priority weights using the reciprocal additive consistent fuzzy preference relation approach.

(1) Based on interviews with twelve representatives regarding the importance of six influential factors, Table 3 lists the pairwise comparison matrices for a set of $n-1$ neighbouring criteria $\{a_{12}, a_{23}, a_{34}, a_{45}, a_{56}\}$.

Table 3. The linguistic terms toward six factors assessed by evaluators

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	
C_1	VT	WE	WE	EQ	ST	WK	WE	EQ	VS	ST	EQ	VS	C_2
C_2	LVLA	ELW	WE	EQ	LST	LWLS	WE	LWK	LVS	ELW	EQ	VT	C_3
C_3	LSLV	ELW	WK	WE	LST	ELW	WK	WE	ST	LWK	EQ	LW LS	C_4
C_4	VT	ELW	LWLS	ELW	ST	WK	ELW	WE	ELW	ELW	EQ	LS LV	C_5
C_5	ST	WE	WE	ELW	LST	EQ	WE	ELW	LWK	LWK	WE	LVS	C_6

(2) Table 4 lists the assessment of evaluator 1 (E_1), which served as an example. Meanwhile, Table 1 lists the fuzzy preference degree while Table 5 lists

the linguistic terms which can be transferred into corresponding numbers.
(3) Eq. (6) was used to transform the elements listed in Table 5 into an interval [0, 1], yielding the following values:

Table 4. Fuzzy preference pairwise comparison matrix of E_1

E_1	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	VT	x	x	x	x
C_2	x	1	LVLA	x	x	x
C_3	x	x	1	LSLV	x	x
C_4	x	x	x	1	VT	x
C_5	x	x	x	x	1	ST
C_6	x	x	x	x	x	1

Table 5. Translated linguistic terms into corresponding number

E_1	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	6	x	x	x	x
C_2	x	1	1/8	x	x	x
C_3	x	x	1	1/6	x	x
C_4	x	x	x	1	6	x
C_5	x	x	x	x	1	5
C_6	x	x	x	x	x	1

$$p_{12} = (1+\log_9 6)/2 = 0.908$$
$$p_{23} = (1+\log_9 \tfrac{1}{8})/2 = 0.027$$
$$p_{34} = (1+\log_9 \tfrac{1}{6})/2 = 0.092$$
$$p_{45} = (1+\log_9 6)/2 = 0.908$$
$$p_{56} = (1+\log_9 5)/2 = 0.866$$

The remaining values can then be calculated by Eqs. (2) and (5), with p_{31}, p_{13}, p_{52} used as examples,

$$p_{31} = \tfrac{3-1+1}{2} - p_{12} - p_{23} = 1.5 - 0.908 - 0.027 = 0.565$$

$$p_{13} = 1 - p_{31} = 1 - 0.565 = 0.435$$

$$p_{52} = \tfrac{5-2+1}{2} - p_{23} - p_{34} - p_{45} = 2 - 0.027 - 0.092 - 0.908 = 0.973$$

Table 6 lists the fuzzy preference relation matrix for six influential factors assessed by evaluator 1. Table 6 lists p_{24} and p_{64} elements not in the interval [0, 1]; thus, a linear transformation stated in Eq. (7) is used to ensure the reciprocity and additive transitivity for the preference relation matrix. Table 7 lists the transformation matrix.

Table 6. Transformed fuzzy preference values of E_1

E_1	C_1	C_2	C_3	C_4	C_5	C_6
C_1	0.500	0.908	0.435	0.027	0.435	0.801
C_2	0.092	0.500	0.027	-0.381	0.027	0.393
C_3	0.565	0.973	0.500	0.092	0.500	0.866
C_4	0.973	1.381	0.908	0.500	0.908	1.274
C_5	0.565	0.973	0.500	0.092	0.500	0.866
C_6	0.199	0.607	0.134	-0.274	0.134	0.500

Table 7. Preference values transformed by linear solution

E_1	C_1	C_2	C_3	C_4	C_5	C_6
C_1	0.500	0.731	0.463	0.231	0.463	0.671
C_2	0.269	0.500	0.231	0.000	0.231	0.439
C_3	0.537	0.769	0.500	0.269	0.500	0.708
C_4	0.769	1.000	0.731	0.500	0.731	0.939
C_5	0.537	0.769	0.500	0.269	0.500	0.708
C_6	0.329	0.561	0.292	0.061	0.292	0.500

(4) Likewise, the above computational procedures can calculate the fuzzy preference relation matrices of the other eleven evaluators; therefore, using Eq. (8), the aggregated pairwise comparison matrix of twelve evaluators can be derived, as Table 8 shows.

Table 8. Aggregated pairwise comparison matrices of 12 evaluators

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	0.500	0.670	0.561	0.559	0.535	0.507
C_2	0.330	0.500	0.391	0.389	0.364	0.336
C_3	0.439	0.609	0.500	0.498	0.474	0.445
C_4	0.441	0.611	0.502	0.500	0.476	0.447
C_5	0.465	0.636	0.526	0.524	0.500	0.472
C_6	0.493	0.664	0.555	0.553	0.528	0.500

(5) Equation (9) is applied to normalize the aggregated pairwise comparison matrix. Taking r_{21} as an example:

$$r_{21} = 0.330/(0.5 + 0.330 + 0.439 + 0.441 + 0.465 + 0.493) = 0.124$$

Equation (10) can then obtain the priority weight of each influential factor. Table 9 lists the priority weight and rank of each influential factor assessed by twelve evaluators. The ranks of the influential factors weights are thus substituted as:

$$C_1(0.185) \succ C_6(0.183) \succ C_5(0.174) \succ C_4(0.165) \succ C_3(0.165) \succ C_2(0.128)$$

Table 9. Normalized matrix of priority weight and rank of influential factors

	C_1	C_2	C_3	C_4	C_5	C_6	Total	Avg	Rank
C_1	0.187	0.182	0.152	0.185	0.186	0.187	1.079	0.185	1
C_2	0.124	0.136	0.106	0.129	0.127	0.124	0.745	0.128	6
C_3	0.164	0.165	0.136	0.165	0.165	0.164	0.959	0.165	5
C_4	0.165	0.166	0.136	0.165	0.165	0.165	0.963	0.165	4
C_5	0.174	0.172	0.143	0.173	0.174	0.174	1.011	0.174	3
C_6	0.185	0.180	0.150	0.183	0.184	0.185	1.066	0.183	2

The analytical results show that the three most influential factors are management support (0.185), industry characteristics (0.183) and government policies (0.174); meanwhile, the three least influential factors are organizational culture (0.165), IT integration (0.165) and firm size (0.128).

4.2 Probable outcomes with respect to influential factors

To determine the priority weight matrix for probable outcomes with respect to each influential factor, Table 2 lists the linguistic variables for evaluators. The priority weights of two probable outcomes were calculated as follows.

(1) Examining the situation of this company, the twelve evaluators were interviewed to assess which is more likely to occur given each influential factor. Table 10 lists the opinions of these twelve evaluators regarding their preference intensities for probable outcomes resulting from each influential factor.

Table 10. The linguistic variables given to the priority weight of probable outcomes

	out	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	out
C_1	S	VH	HF	HF	LHF	H	H	VH	HF	H	LH	LH	H	F
C_2	S	LVHG	VH	LH	LHF	H	H	HF	HF	VH	H	LHF	H	F
C_3	S	F	LVH	LH	LH	LVH	F	F	LH	F	LH	H	LH	F
C_4	S	H	LHF	LHF	LHF	H	HF	HF	HF	VH	LHF	LHF	F	F
C_5	S	HF	HF	VHG	LHF	HF	H	VH	VH	H	LH	H	HF	F
C_6	S	LH	H	H	LHF	LHF	HF	HF	F	VH	H	H	H	F

(2) The linguistic variables were translated into the corresponding numbers listed in Table 2. The function $p_{ij} = \frac{1}{2}(1 + \log_5 a_{ij})$ was then used to transform the values in the scale $[\frac{1}{5},\ 5]$ into the interval [0, 1].

(3) Using Eq. (11), and taking ${}_1q_{uv}$ as an example, the synthetic rating of probable outcomes can be obtained, as Table 11 shows, where ${}_1q_{uv}$ represents the transformed fuzzy preference value of twelve evaluators for assessing probable outcomes u and v in terms of influential factor 1.

Table 11. Aggregated pairwise comparison matrices 12 evaluators of C_1

C_1	S	F
S	0.500	0.670
F	0.330	0.500
Total	0.830	1.170

Equations (12)-(13) can then be employed to normalize and synthesize the fuzzy preference rating of two probable outcomes based on six influential factors. Table 12 lists the normalized values and priority weights, and Table 13 lists the normalized values and priority weights of all criteria.

Table 12. Normalized matrix of priority weight of C_1

C_1	S	F	Total	Average
S	0.602	0.573	1.175	0.587
F	0.398	0.427	0.825	0.413
Total			2.000	1.000

Table 13. All criteria and preference rate of probable outcomes

		Priority weight		Weighted rate	
	weight	S	F	S	F
C_1	0.185	0.587	0.413	0.109	0.076
C_2	0.128	0.566	0.434	0.072	0.056
C_3	0.165	0.413	0.587	0.068	0.097
C_4	0.165	0.531	0.469	0.088	0.077
C_5	0.174	0.619	0.381	0.108	0.066
C_6	0.183	0.576	0.424	0.105	0.078
Total				0.550	0.450

4.3 Weighting the predication priorities

As Table 13 shows, Eq. (14) is used to determine the priority weights of six influential factors and the priority ratings of two probable outcomes in addition to the preference weightings of the candidates. From Table 13, the ranking of probable outcomes of e-commerce implementation is obtained as follows: Success S (0.550) > Failure F (0.450). Evaluators clearly believe that the probable outcome of B2B e-commerce implementation for SMEs is "success".

5 Conclusions

Based on the opinions of all survey respondents, the following findings were obtained:

Analytical results indicate that management support, industry characteristics and government policies are more important than other factors. Meanwhile, the prediction weights for six influential factors affecting probability of failure were: management support (0.413), firm size (0.434), IT integration (0.587), organizational culture (0.469), government policies (0.381) and industry characteristics (0.424).

Notably, other than government policies, the probability of failure for all influential factors exceeded 0.4. This analytical result also demonstrates that B2B e-commerce implementation in this company may break down. The company should be more concerned with seeking support from top managers, increasing firm size, improving IT integration and IT sophistication or changing the organizational culture to increase the likelihood of success in implementing B2B e-commerce.

The multi-criteria decisionmaking model for predicting the success of B2B e-commerce implementation presented here is clearly applicable to the evaluation process. Application of the proposed approach is clearly faster and more efficient than the conventional analytic hierarchy methodologies. This advantage is a key contribution of this study. The findings of this study provide a reference for managers and decision makers considering implementation of B2B e-commerce in small and medium enterprises.

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