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Selecting the Best Supplier by Considering Supply Chain Management Strategy and Utilizing Uncertainty Parameters

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Abstract

Today, the intensity of competition in market has forced companies to consider supply chain management strategy (SCMS) deployment and its modern methods in order to achieve competitive advantages. Supplier selection, among critical supply chain processes, plays a leading role in determination of quality and prime cost of final products. In this paper fuzzy analytic network process is proposed to select the best supplier in SCMS, because of its capability of taking into account the relationships of feedback and dependences among criteria, along with eliminating the interactivity of expert subjective judgment using linguistic terms to handle the uncertain nature of parameters.

Keywords: Supply chain management strategy (SCMS), Fuzzy set theory, Analytic network process (ANP), Supplier selection.

1. Introduction

Nowadays, competitive in market is extremely increasing. Firms need to maintain their competitive edge and make a decent profit. More specifically, require reorganizing their supply chain management strategy (SCMS) to harmonize with the external environments by integrating the organizational resources, information, and activities (Tseng, M.- L., et al, 2009).

In previous decades, supplier selection problem has been noticed as an important problem in both industry and science. It can result in better and more efficient services/products due to cooperating with suppliers (Degraeve et al, 2001). Therefore, outsourcing has become the valuable procedure in business (mccarthy et al, 2004). Lin and Chen (2004) did a comprehensive review of literature and identified 183 decision attributes for evaluating candidate supply chain alliances for general industries (Lin et al, 2004; Lee, 2008).

Supplier selection process has been considered as a multiple criteria decision making (MCDM) problem which contains both tangible and intangible factors. If process is done correctly, a higher quality and longer lasting relationship is more attainable (Lee, 2008). In other word, selection of wrong supplier could be enough to upset the company's financial and operational position. However, selecting the right suppliers significantly reduces purchasing cost, improves competitiveness in market and enhances end user satisfaction (Önüt et al, 2009).

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Besides all of the published articles about criteria of selecting the best supplier, many papers have presented various methods and procedures. Most of them are MCDM methods as instance mathematical programming (MP), goal programming (GP), heuristic algorithms such as genetic algorithm (GA), etc, which all making efforts in order to simplifies the process with more accuracy and also seek some objectives such as the order quantity, capacity, etc. The mathematical programming (MP) includes linear programming (LP) and combination linear programming. Goal programming (GP) has been studied by itself and applied in supplier selection by so many researchers, Such as Weber et al (1998), Lee (2008). While presenting different types of supplier selection methods, a few articles applied compensatory methods for supplier selection. In presented article, by considering literature, the FANP is applied to select appropriate suppliers. The other sections of this article are as follows:

Background of SCMS and hierarchical structure of SCMS are in placed in sections 2 and 3 respectively. Section 4 demonstrates our proposed model in order to selecting the best supplier, section 5 contains results obtained from implementing the model. At last the conclusion and future research are expressed in section 6.

2. Background of SCMS

In a well organized supply chain, the coordination of layers in supply chain is an important issue. If the cooperation of these parts cannot be managed in the best way it can result in wasting time and energy so the supply chain will encounter too much cost in order that deliver the product to customers. Supply chain management strategy (SCMS) is used to explain the planning and control of materials/information flows and logistics activities, not only internally within a firm but also externally between firms (Cooper, Ellram, Gradner, & Hanks et al 1997; Seo, 2006). The key concept is that the channel is viewed as an integrated whole, with the goal of understanding the channel as an application system. Each firm in the channel affects, directly or indirectly, all the other channel members, as well as the ultimate, overall channel performance (Beamon, 1999; Handfield & Nichols, 1999; Tan, Kannan, & Handfield, 1998).

The main characteristic of a well developed SCMS is its ability to align logistic processes with supply chain management policies which is not easily cheatable by competitors. Numerous criteria and attributes must be considered when evaluating the SCMS. In this study, we emphasize the following five criteria: customer focus (which highly considers methods of understanding customer needs and satisfying customer requirements), competitive priority, information technology, strategic purchasing, and top management support.

According to above, the SCMS models on supplier evaluation are in essence multi-dimensional, complex, and interdependency activities (Yao et al., 2007). The SCMS models on supplier evaluation permitting intuitive judgment have garnered acceptance by various experts, including scholars and SCM professionals. To assist the expert group to select the preferred suppliers in SCMS contexts this study proposes an effective hierarchical evaluation framework by explicitly describing the decision structure of SCMS upon which pair comparison subjective judgments of experts can base.

3. Hierarchical structure of SCMS

The foundation of our SCMS model is based on an extracted example from literature (Tseng, M.- L. Et al, 2009) which previously had been solved by the classic ANP and choquet integral. We revised the model and found out that some interrelations between criteria have been overlooked. Thus the new model of SCMS hierarchical structure with interrelations between uncertain determinants is designed (Fig. 1). The criteria and their associated attributes are discussed as follows.

First, the customer focus (C1) is the goal of businesses, which is to ‘‘create and maintain customers”. The attributes for customer focus construct contain the responses to customers evolving needs and wants (A11), evaluation of customer complains(A12), products satisfying customer expectation (A13) and satisfying customer needs—the central purpose of business plan (A14) (Hwang, 1998). Secondly, the competitive priority (C2) is a common success theme of operations strategy. The attributes in this construct contain offering products with lowest price (A21), greater emphasis on innovation (A22), launching new product quickly (A23), and quality performance (A24) (Chenhall et al.1998). Thirdly, the strategic purchasing (C3) is critical to facilitate close interactions with a limited number of suppliers and making effective use of the firm’s supply base (Cousins, 1999). Three attributes in this construct are considered: purchasing function with a formally written long-range plan (A31), purchasing focus on longer term issues (A32), and purchasing performance measured (A33) (Carr et al., 1999). Fourthly, all the SCMS activities are involved with the top management support (C4). This construct emphasizes such attributes as purchasing function strategic role (A41), supporting the competitive priority with company mission (A42), supporting the need for inter-organizational information system (A43), and accounting for customer needs a vital part of corporate strategy (A44) (Chen et al., 2004). Lastly, the information integration needs the information technology (C5) to be applied in SCMS. The complete integration into SCMS with electronic commerce component also aids in the evolution of SCMS. The attributes in this construct include a direct link of computers to computers with key suppliers (A51), inter-organizational coordination achieved by electronic links (A52), and using IT-enabled transaction processing (A53) (Carr et al., 1999).

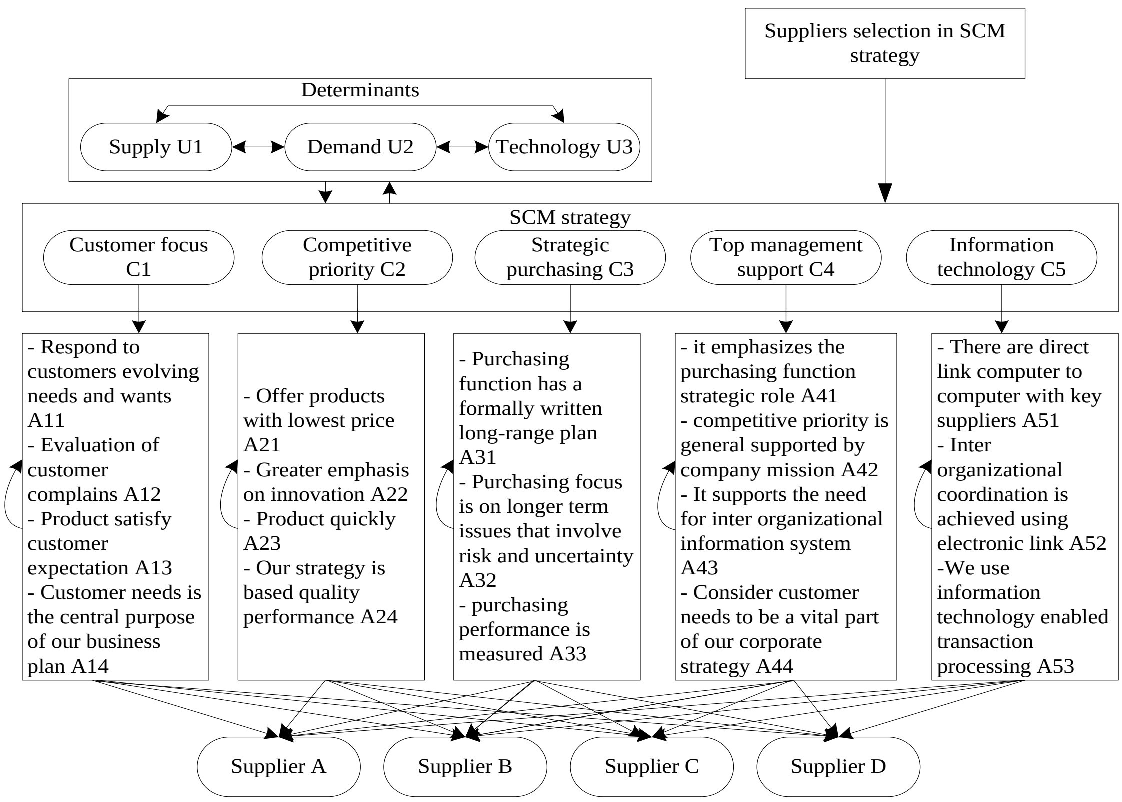

Figure 1. SCMS hierarchical structure.

4. Fuzzy analytic network process (FANP)

Analytic Hierarchy Process (AHP) was proposed by Saaty (1980) as a multiple criteria decision making method and has been used to solve a wide range of problems. The basic assumptions of AHP are that it can be used in functional independence of an upper part or cluster of the hierarchy from all its lower parts and the criteria or items in each level (Meade & Sarkis, 1999). Many decision-making problems cannot be structured hierarchically because they involve the interaction and dependence of higher level elements on lower level elements (Saaty & Takizawa, 1986; Saaty, 1996), and must be structured as a network system to allow feedback, dependencies and interrelationships among criteria. Therefore, Saaty (1996) proposed analytic network process (ANP) as a new analysis method.

The analytic network process (ANP) extends the AHP to problems with dependencies and feedback among the criteria and alternatives by using a ‘‘supermatrix’’ approach (Saaty, 1996). The supermatrix is a segmented matrix, where each submatrix is composed of a set of relationships between two components or clusters in a connection network structure. If there is no interdependent relationship among the criteria, the pairwise comparison value would be 0. In contrast, if an interdependent and feedback relationship exists among the criteria, then such value would no longer be 0 and an unweighted supermatrix M will be achieved. We then get the limited weighted supermatrix M^* based on Eq. (1) and allow for progressive convergence of the interdependent relationship to achieve the precise relative weights among the criteria.

$$M^* = \lim_{k\to\infty} M^k \qquad (1)$$

Nevertheless, both AHP and ANP methods deal only with comparison ratios which are crisp but usually, most of parameters are uncertain. To deal with this problem due to vagueness and imprecision, the fuzzy set theory is introduced by Zadeh (1965) and afterwards various authors proposed many fuzzy AHP and FANP methods. Also, choquet integral is a non-additive integral that can eliminate the interactivity of expert subjective judgment problems. In order to cope with this problem, it was combined ANP with choquet integral to eliminate the interactivity of expert subjective judgment problems and select the preferred suppliers, (Tseng, M.-L. et al, 2009). But this approach is complicated and may lead to miscalculate and incorrect ranking of suppliers. In this study, we preferred Chang’s (1992) extent analysis method because the steps of this approach are easier than other fuzzy ANP and choquet integral approaches.

5. Proposed supplier selection model

The proposed model to select preferred supplier is composed of following steps:

Step 1: Identify the factors and sub-factors to be used in the model and then structure the ANP model hierarchically (goal, factors, sub-factors).

Step 2: Determine local weight of the factors and sub-factors by using pairwise comparison matrices. The fuzzy scale regarding relative importance is utilized to measure the relative weights (Table 1). Calculate the maximum eigenvalues and the corresponding eigenvectors of the pairwise comparison matrices to generate the supermatrix. Afterwards limit the weighted supermatrix for the weigh by using Eq. (1).

Step 3: Calculate the global weights for the sub-factors by multiplying local weight of the sub-factor with the interdependent weights of the factor to which it belongs.

Table 1. Linguistic scales for difficulty and importance.

Linguistic scale for difficulty	Linguistic scale for importance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Just equal	Just equal	(1,1,1)	(1,1,1)
Equally difficult	Equally important	(1/2, 1,3/2)	(2/3, 1,2)
Weakly more difficult	Weakly more important	(1,3/2, 2)	(1/2, 2/3, 1)
Strongly more difficult	Strongly more important	(3/2, 2,5/2)	(2/5, 1/2, 2/3)
Very strongly more difficult	Very strongly more important	(2,5/2, 3)	(1/3, 2/5, 1/2)
Absolutely more difficult	Absolutely more important	(5/2, 3,7/2)	(2/7, 1/3, 2/5)

Step 4: Measure the sub-factors. Linguistic variables proposed by Cheng et al. (1999) are used in this step. The average values related with these variables are shown below (Table 2). While using this evaluation scale, the linguistic variables can take different values depending on the structure of the sub-factor.

Step 5: Calculate the weight of each supplier by using the simple additive weighting (SAW) method.

Table 2. Linguistic values and mean of fuzzy numbers.

Linguistic values	The mean of fuzzy number
Very High (VH)	1.00
High (H)	0.75
Medium (M)	0.50
Low (L)	0.25
Very Low (VL)	0.00

6. Result and discussion:

Expert opinions are obtained from an expert group of five professors and six senior managers and interpreted in terms of numbers as shown in table 1, the average of resulted numbers are then used in next steps. For example: in table 3, C1 in comparison with C2 (1, 1 2/9, 1 1/2) shows the average of Linguistic scale for difficulty.

Preferred suppliers are selected by using the proposed method provided in previous section and explained step by step together with the results.

Step 1: The model consists of three determinants, five criteria and eighteen sub-criteria, all of which are determined by literature review. The ANP model is shown in Fig. 1. Step 2: In this step, a series of pairwise comparisons are made to calculate local weights of the factors and sub-factors which take part in the model. Some of these matrices are provided below (table 3-5).

Table 3. Pairwise comparison matrix for criteria in determinant (U1).

U1	C1	C2	C3	C4	C5	Local Weight
C1	(1,1,1)	(1,1 2/9, 1 1/2)	(1 3/8, 1 7/8,2 3/8)	(2/3,5/6,1)	(1,1 3/8, 1 5/7)	0.257
C2	(2/3, 4/5, 1)	(1,1,1)	(5/6, 1 1/8, 1 1/2)	(1, 1 3/8, 1 4/5)	(4/5, 1, 1 1/4)	0.207
C3	(3/7, 1/2 , 5/7)	(2/3, 8/9, 1 1/5)	(1,1,1)	(1 2/9, 1 5/8, 2)	(1 3/8, 1 4/5, 2 1/4)	0.235
C4	(1, 1 1/5, 1 5/9)	(5/9, 5/7, 1)	(1/2, 5/8, 4/5)	(1,1,1)	(1 1/9, 1 2/5, 1 4/5)	0.187
C5	(3/5, 5/7, 1)	(4/5, 1, 1 1/4)	(4/9, 5/9, 5/7)	(5/9, 5/7,1)	(1,1,1)	0.114

For example table 3 shows the pairwise comparison of criteria under determinant (U1) along with the eigenvector. The normalized results under determinants U1, U2 and U3 are, respectively, U1(0.257, 0.207, 0.235, 0.187, 0.114), U2 (0.301, 0.282, 0.202, 0.181, 0.034) and U3 (0.295, 0.305, 0.217, 0.183, 0.000). All pairwise comparison matrices are produced in the same procedure.

Table 4. Pairwise comparison matrix for determinant in criteria (C1).

C1	U1	U2	U3	Local Weight
U1	(1,1,1)	(1 1/5, 1 1/2, 1 5/6)	(1 1/5, 1 3/5, 2)	0.572
U2	(5/9, 2/3, 5/6)	(1,1,1)	(5/6, 1 1/8, 1 1/2)	0.250
U3	(1/2, 5/8, 5/6)	(2/3, 8/9, 1 1/5)	(1,1,1)	0.178

Table 5. comparison matrix for interrelations between determinants.

U1	U2	U3	Local weight
U2	(1,1,1)	(1/2,1, 1 1/2)	0.500
U3	(2/3,1,2)	(1,1,1)	0.500

After that, the unweighted supermatrix must be constructed (Table 6) and subsequently the weighted supermatrix (Table 7) can be raised to limiting powers to calculate the priority weights by normalizing table 6 and using Eq. (1).

Table 6. Unweighted supermatrix for interdependency among determinants and SCM strategy.

	Determinants			SCMS				
	U1	U2	U3	C1	C2	C3	C4	C5
U1	0.000	1.000	0.684	0.572 (Table 3)	0.629	0.466	0.522	0.664
U2	0.500 (Table 5)	0.000	0.316	0.250	0.230	0.295	0.256	0.313
U3	0.500	0.000	0.000	0.178	0.141	0.239	0.222	0.023
C1	0.257 (Table 4)	0.301	0.295	0.000	0.000	0.000	0.000	0.000
C2	0.207	0.282	0.305	0.000	0.000	0.000	0.000	0.000
C3	0.235	0.202	0.217	0.000	0.000	0.000	0.000	0.000
C4	0.187	0.181	0.183	0.000	0.000	0.000	0.000	0.000
C5	0.114	0.034	0.000	0.000	0.000	0.000	0.000	0.000

Table 7. Unweighted supermatrix for interdependency among determinants and SCM strategy.

	Determinants			SCMS				
	U1	**U2**	**U3**	**C1**	**C2**	**C3**	**C4**	**C5**
U1	0.568	0.568	0.568	0.000	0.000	0.000	0.000	0.000
U2	0.274	0.274	0.274	0.000	0.000	0.000	0.000	0.000
U3	0.158	0.158	0.158	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.278	0.278	0.278	0.278	0.278
C1	0.000	0.000	0.000	0.255	0.255	0.255	0.255	0.255
C2	0.000	0.000	0.000	0.223	0.223	0.223	0.223	0.223
C3	0.000	0.000	0.000	0.185	0.185	0.185	0.185	0.185
C4	0.000	0.000	0.000	0.059	0.059	0.059	0.059	0.059
C5	0.568	0.568	0.568	0.000	0.000	0.000	0.000	0.000

The converged supermatrix presents the results of the relative importance measures for determinants and SCMS. The ingredients of Supermatrix of sub-criteria in interdependency relationships before convergence have been imported from the pairwise comparison matrices of interdependencies (Table 8), and converged supermatrix is constructed to obtain a stable set of weights (Table 9).

Table 8. Supermatrix of attributes in interdependency relationships before convergence.

	A11	**A12**	**A13**	**A14**	**A21**	**A22**	**A23**	**A24**	**A31**	**A32**	**A33**	**A41**	**A42**	**A43**	**A44**	**A51**	**A52**	**A53**
A11	0.000	0.407	0.413	0.180	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A12	0.733	0.000	0.267	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A13	0.755	0.245	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A14	0.752	0.188	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A21	0.000	0.000	0.000	0.000	0.000	0.602	0.240	0.158	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A22	0.000	0.000	0.000	0.000	0.445	0.000	0.265	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A23	0.000	0.000	0.000	0.000	0.441	0.343	0.000	0.215	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A24	0.000	0.000	0.000	0.000	0.643	0.357	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.858	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.770	0.000	0.230	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A41	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.558	0.442	0.000	0.000	0.000	0.000
A42	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.342	0.000	0.534	0.124	0.000	0.000	0.000
A43	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.722	0.278	0.000	0.000	0.000	0.000	0.000
A44	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.520	0.359	0.121	0.000	0.000	0.000	0.000
A51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.684	0.316
A52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.589	0.000	0.411
A53	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000

Table 9. Converged Supermatrix of sub-criteria in interdependency relationships.

	A11	A12	A13	A14	A21	A22	A23	A24	A31	A32	A33	A41	A42	A43	A44	A51	A52	A53
A11	0.427	0.249	0.247	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A12	0.427	0.249	0.247	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A13	0.427	0.249	0.247	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A14	0.427	0.249	0.247	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A21	0.000	0.000	0.000	0.000	0.332	0.321	0.165	0.181	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A22	0.000	0.000	0.000	0.000	0.332	0.321	0.165	0.181	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A23	0.000	0.000	0.000	0.000	0.332	0.321	0.165	0.181	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A24	0.000	0.000	0.000	0.000	0.332	0.321	0.165	0.181	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.455	0.390	0.154	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.455	0.391	0.154	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.455	0.391	0.154	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A41	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.350	0.296	0.317	0.037	0.000	0.000	0.000
A42	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.350	0.296	0.317	0.037	0.000	0.000	0.000
A43	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.350	0.296	0.317	0.037	0.000	0.000	0.000
A44	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.350	0.296	0.317	0.037	0.000	0.000	0.000
A51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.438	0.300	0.262
A52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.438	0.300	0.262
A53	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.438	0.300	0.262

Step 1: Global sub-criteria weights are computed by multiplying the weight of the criteria (Table 7) with the local weight of the sub-criteria (Table 9) to which it belongs (Table 10).

Step 2: The sub-factors are measured by multiplying global weight value of sub-criteria (Table 10, fifth column) with Linguistic variables (Table 1).

Table 10. FANP computation of overall weight index for alternatives.

Criteria	Weight	Sub-criteria	Local Weight	Global Weight (GW)	Linguistic Variable	Scale Value	GW× SV	Sup. 1	Sup. 2	Sup. 3	Sup. 4
C1	0.278	A11	0.427	0.119	M	0.50	0.0594	0.222	0.333	0.222	0.222
		A12	0.249	0.069	L	0.25	0.0173	0.250	0.250	0.250	0.250
		A13	0.247	0.069	H	0.75	0.0516	0.474	0.175	0.175	0.175
		A14	0.077	0.021	M	0.50	0.0107	0.333	0.222	0.222	0.222
C2	0.250	A21	0.332	0.083	M	0.50	0.0415	0.042	0.068	0.507	0.383
		A22	0.321	0.080	H	0.75	0.0602	0.154	0.196	0.379	0.271
		A23	0.165	0.041	H	0.75	0.0309	0.224	0.252	0.224	0.299
		A24	0.181	0.045	VH	1.00	0.0453	0.224	0.252	0.224	0.299
C3	0.221	A31	0.455	0.101	VH	1.00	0.1008	0.297	0.251	0.186	0.265
		A32	0.390	0.086	VH	1.00	0.0865	0.278	0.244	0.200	0.278
		A33	0.154	0.034	VH	1.00	0.0342	0.271	0.250	0.209	0.271
C4	0.184	A41	0.350	0.064	VH	1.00	0.0645	0.266	0.311	0.243	0.180
		A42	0.296	0.055	VH	1.00	0.0546	0.251	0.297	0.265	0.186
		A43	0.317	0.059	VH	1.00	0.0585	0.220	0.394	0.293	0.093
		A44	0.037	0.007	VH	1.00	0.0068	0.252	0.278	0.244	0.226
C5	0.066	A51	0.438	0.029	H	0.75	0.0218	0.246	0.228	0.277	0.249
		A52	0.300	0.020	H	0.75	0.0149	0.250	0.250	0.250	0.250
		A53	0.262	0.017	H	0.75	0.0130	0.250	0.250	0.250	0.250

Step 3: The simple additive weighting method are used in this step to calculate the additive weight of each supplier. As the results obtained using the proposed method (table 11), supplier 2 is the best among the other suppliers and thereafter suppliers 3, 1 and 4 are preferred respectively.

Table 11. The results

Supplier	SAW
1	0.1946
2	0.1975
3	0.1951
4	0.1852

7. Conclusion and future research

Selection of the preferred supplier in SCMS is completely necessary for firms to achieve competitive advantages. Unlike the referenced article that assumed uncertainty determinants to behave independently in decision making process, we have modified the previous model to recognize interrelationships between aforementioned determinants. Fuzzy analytic network process has been employed to select the most appropriate supplier in SCMS. The introduced method is observed to posses certain advantages over formerly practiced methods in terms of accuracy of handed results when compared to ANP, and simplicity in linguistic-term-based elimination of expert subjective judgment interactivity in comparison with choquet integral. The proposed method enables decision maker to verify the accuracy of the results and avoid miscalculations and ensure flawless ranking of suppliers in order to have the best combination of quality, cost and time in supply chain management strategy deployment. There are two major aspects requiring improving in the future research work. First, future studies could develop a multi-hierarchical structure that incorporates other factors with quantitative and qualitative measurement. Second, we can apply MCDM methods that are newly developed and comparison plan of results.

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