A VENDOR SELECTION TECHNIQUE BASED ON ANALYTICAL HIERARCHY PROCESS WITH VECTOR ANALYSIS

เทคนิคการเลือกผู้จำหน่ายโดยการใช้กระบวนการลำดับชั้นเชิงวิเคราะห์และการคำนวณแบบเวคเตอร์

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Abstract

Selection of the right vendor is an important process for business today. Many techniques are reserved for this function. In this work, an improvement of Analytic Hierarchy Process (AHP) with vector analysis technique is proposed for vendor selection process. The proposed technique is evaluated by using a case study of a company based on six criteria to be considered, including price, quality, delivery, productivity, service, and support. Four candidate vendors are applied in this work. The conventional techniques, including AHP and Decision Matrix techniques, are used for comparing with the proposed technique. The experimental results show that the ranking result from the Decision Matrix technique is similar to the ranking result of the proposed technique, while it is different from the rankings result of AHP. These ranking results are considered and finalized by an expert and are concluded that the result of the proposed technique is preferable than the conventional techniques.

Keywords: Analytic hierarchy process, Multiple criteria decision making, Vendor selection

บทคัดย่อ

การคัดเลือกผู้จำหน่ายเป็นขั้นตอนที่มีความสำคัญสำหรับองค์กรและการประกอบธุรกิจในปัจจุบัน ซึ่งขั้นตอนดังกล่าวสามารถทำได้หลายวิธี สำหรับงานวิจัยนี้ได้นำเสนอการปรับปรุงพัฒนากระบวนการลำดับชั้นเชิงวิเคราะห์ (Analytic Hierarchy Process) โดยใช้หลักการคำนวณแบบเวคเตอร์ เพื่อนำมาช่วยในการตัดสินใจคัดเลือกผู้จำหน่ายขององค์กร โดยได้นำตัวอย่างกรณีศึกษาจากบริษัทหนึ่งภายใต้ปัจจัยด้านต่างๆ ทั้งหมด 6 ด้าน ได้แก่ ด้านราคา ด้านคุณภาพ ด้านการส่งมอบงาน ด้านความสามารถในการผลิต ด้านบริการ และด้านบริการหลังการขาย โดยศึกษาจากผู้จำหน่ายจำนวน 4 บริษัท ซึ่งวิธีการที่นำเสนอในงานวิจัยชิ้นนี้จะเปรียบเทียบผลที่ได้กับวิธีกระบวนการลำดับชั้นเชิงวิเคราะห์และวิธีการประเมินแบบเมตริกซ์ตัดสินใจ (Decision Matrix) ผลจากการทดลองพบว่า วิธีการที่นำเสนอ

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ในงานวิจัยชิ้นนี้มีความสอดคล้องกับผลที่ได้จากวิธีการประเมินแบบเมตริกซ์ตัดสินใจ ในขณะที่ผลที่ได้จากวิธีการที่นำเสนอในงานวิจัยนั้นแตกต่างกับผลที่ได้จากกระบวนการลำดับชั้นเชิงวิเคราะห์ โดยขั้นตอนสุดท้ายผู้เชี่ยวชาญจะเป็นผู้ตัดสินผลของการคัดเลือกผู้จำหน่ายซึ่งสามารถสรุปได้ว่า ผลจากวิธีการที่นำเสนอในงานวิจัยชิ้นนี้ให้คำตอบที่ตรงกับความต้องการมากกว่าวิธีดั้งเดิม

คำสำคัญ: กระบวนการลำดับชั้นเชิงวิเคราะห์ การเลือกผู้จำหน่าย การตัดสินใจแบบพิจารณาหลายเกณฑ์

Introduction

Vendor selection process is sometimes very complex. Many organizations fail to achieve the expected performance results from vendors. The objective of the vendor selection process is to reduce risk, maximize the total value, get higher profit margin, and increase customer satisfaction. However, a vendor, who is fit for a company, may not necessarily be a suitable choice for another. This study starts with the need of a company that prefers to select a right vendor. The selection of vendors is one of the multiple criteria decision making (MCDM) (Aruldoss, 2013; Ishizaka & Nemery, 2013)

Analytic Hierarchy Process (AHP), which was introduced by Saaty (2008), has emerged as a major tool in multi-criteria decision analysis. The process of this technique has been well documented by Saaty and many case studies which this technique have been using and reporting by many pieces of research (Aruldoss, 2013; Greer & Ruhe, 2004; Kousalya et al., 2012). However, there are some weak points of AHP process, which reported by several works such as (Belton, 1986) and (Belton & Gear, 1997), which stated on the computational and process complexity, while Holder (1990) and Hajkowicz, McDonald & Smith (2000) pointed out the problem of the scale used for pairwise comparisons. Triantaphyllou & Mann (1995) mentioned the weakness in the additional process to calculate the total score which might not be a suitable way to add the values of the different domain.

From the weaknesses of AHP as described above, some of them can be solved by using a computer software such as computational and process complexity. However, there is the issue that does not have any study on it, which is a summation of the total score of AHP as mention by Triantaphyllou & Mann (1995). This issue is a mathematical perspective, which can be considered as an important issue. According to AHP process, the final step of AHP will be the addition of the score in the different units if the criteria are expressed in different units. These might not be reasonable to add up values in different units or domains in mathematical term even though the weighting method is adapted to compensate. Therefore, to overcome this issue, vector analysis is applied in this work.

There are two objectives of this work. The first one is to investigate the vendor selection process and the second one is to improve the AHP by using vector analysis.

Literature Review

1. Vendor Selection

Efficient vendor selection aims to find out a vendor who can provide products and services at the right time, right quantity, and right price with required quality (Mandal & Deshmukh, 1994). The selection of vendors has to be considerate of several factors (Liu & Hai, 2005; Wadhwa & Ravindran, 2007). Many decision-making techniques are used for vendor selection in many pieces of research (Petroni & Braglia, 2000; Weber & Ellram, 1993).

1.1 Vendor Selection Process

Basically, vendor selection process comprises of four phases, given as realization of the need of new vendor, determination and formulation of vendor criteria, pre-qualification of potential vendors, and final vendor selection (De Boer & Van Der Wegen, 2003).

1.2 Vendor Selection Method

The vendor selection method should have certain characteristics such as: be comprehensive, objective, reliable, and flexible enough. There are several vendor selection methods available in the literature (Ellram, 1995; Hill & Nydick, 1992; Petroni & Braglia, 2000).

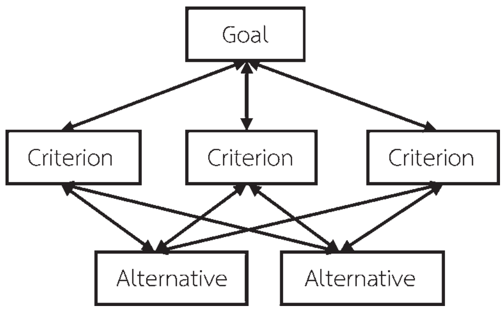

Figure 1 A simple structure of AHP hierarchy

Many studies proposed the use of AHP as a consistent and appropriate methodology to determine the relative importance of criteria and the performance of vendors/suppliers versus each criterion. More details about the AHP will be discussed in next topic.

1.3 Vendor Selection Criteria

Vendor selection is sometimes complicated when there are many criteria considered in the decision-making process. The success of vendor selection process depends on the quality of criteria (Bello, 2003). Weber & Ellram (1993) have surveyed the top ranks of criteria for vendor selection, which indicated the (net) price, delivery (time) and quality as the most important vendor selection criteria.

2. Analytic Hierarchy Process

This work studies about Analytic Hierarchy Process (AHP) to support the decision-making process. The AHP is a modern decision-making method developed by Saaty (1980) for prioritizing alternatives when multiple criteria must be considered and allow the decision maker to structure complex problems in the form of a hierarchy. The final outcome is a score of each alternative.

The AHP has a hierarchical scale of any complexity and problems of multi-criteria. It is based on three steps.

2.1 First Step: Hierarchy Construction

The first step is to define the problem. Then, put all elements in a hierarchy as shown in Figure 1. The top part is the main objective or goal, where the bottom part is the alternatives that contribute to the goal through the middle criteria. The middle part of the hierarchy covers the goal and the alternatives. Representing them in a hierarchy is an effective way to visualize and define the problem and its components to deal with the complexity.

2.2 Second Step: Pairwise Comparison

After establishing the hierarchy, the second step is to evaluate each set of criteria in pairs then the pairwise comparison matrices are constructed. Each member of matrices is obtained from the pairwise comparison process, where pairwise comparison are appraised of a pair of criteria or alternatives. These pairwise comparisons use a discrete scale introduced by Saaty (1980) to evaluate the preferences of comparison. According to this scale, the value of comparisons is a member of the set: {9, 8, 7, 6, 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9}. For example, suppose 3 criteria, i.e., A, B and C, be compared with pairwise comparison technique. Assume the criterion B is preferable than the criterion A with a value of 9, the criterion C is preferable than the criterion B with a value of 5, and the criterion C is preferable than the criterion B with a value of 7. The pairwise comparison matrix can be constructed as shown in Table 1.

Table 1 An example of pairwise comparison matrix

	Criterion A	Criterion B	Criterion C
Criterion A	1	9	5
Criterion B	1/9	1	7
Criterion C	1/5	1/7	1

This is repeated for all the criteria in the column on the left. The lower diagonal is filled using

$$a_{j,i} = \frac{1}{a_{i,j}}, \quad (1)$$

where $a_{j,i}$ is the element of row i column j of the matrix. This pairwise comparison needs to construct for all levels of hierarchy. It means that several of matrices for criteria, sub-criteria, and alternatives are constructed.

Note that consistency of these matrices needs to be verified before conducting the next step. The consistency of comparison means that the given score of each criterion is reasonable. For example, if the score of criterion A more than the score of criterion B and the score of criterion B more than the score of criterion C, it will be consistency only if the score of criterion A more than the score of criterion C. Otherwise, it is not consistency. The consistency ratio (CR) is defined in (Saaty, 1980) as follows:

$$CR = \frac{CI}{RI}, \quad (2)$$

where CI is consistency index and RI is random index. The value of CI is calculated by

$$CI = (\lambda_{max} - n)/(n - 1), \quad (3)$$

where λ_{max} is the maximum eigenvalue of pairwise comparison matrix and n is a number of comparison object. More details on computing CR can be found in (Triantaphyllou & Mann, 1995). The value of CR must be less than 0.1 to accept the consistency of the matrix. Otherwise, some of the element needs to be fixed.

2.3 Third step: computation of eigenvectors and ranking

The third step is to establish the eigenvector for criteria and sub-criteria matrices. The eigenvector is a vector of weighting factors to be multiplied with each criterion and sub-criteria for computing the ranking of an alternative. The eigenvectors can be obtained from

$$P \times v = \lambda v, \quad (4)$$

where v is an eigenvector, λ is eigenvalue and

$$P = \begin{bmatrix} 1 & a_{1,2} & \cdots & a_{1,N} \\ 1/a_{1,2} & 1 & \cdots & a_{2,N} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1,N} & 1/a_{2,N} & \cdots & 1 \end{bmatrix}. \quad (5)$$

The numerical method could be utilized to compute v and λ. The v is a vector or a column matrix which contain the weighting factor as follows

$$v = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_N \end{bmatrix}, \quad (6)$$

where w_1 is weight factor associated with the first criteria, w_2 is weight factor associated with the second criteria and so on.

Finally, a decision matrix of the alternatives, denoted by A_j, of all the criteria combined are determined by the following equation.

$$A_j = \sum_{i=1}^{N} a_{i,j} w_i \text{ for } j = 1, 2 \ldots M, \quad (7)$$

where M is a number of alternative and N is a number of criterion. The best alternative is the one that gives maximum value, denoted by $A_{\text{bst, wsm}}$, i.e.,

$$A_{bst,\ wsm} = \max\{A_i\} \text{ for } i = 1, 2 \ldots \text{M}, \quad (8)$$

where max{.} is the maximum notation. The model is called weighted sum model (WSM) (Fishburn, 1967).

An Improvement of AHP with Vector Analysis Model

According to AHP procedure, a total score of each alternative is computed from the summation of the weighted score of each criterion (w_j) multiply with the pairwise score (a_{ij}) which is a scalar computation as shown in equation (7). However, mathematically, some kind of criteria, which have different quantities, cannot be compared or manipulated in scalar manner. For example, some criteria are quantitative such as price, quality, and capacity. To avoid this problem, Vector Analysis Model (VAM) is proposed to replace the scalar summation which is the last step of AHP process.

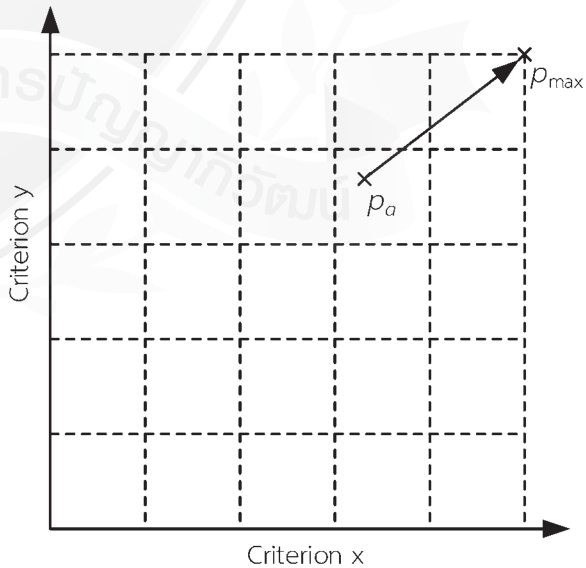

Figure 2 Example of selection alternative based on vector analysis model

Considering Figure 2, two-dimension of vector space is used for describing the concept of proposed idea where the x-axis represents the criterion x while the y-axis represents the criterion y. The maximum value of preferring based on the first criterion is $x_{\max}$ and the maximum value of preferring based on the second criterion is $y_{\max}$. Therefore, the highest value of the test is at ($x_{\max,}$ $y_{\max}$) as shown in Figure 2. However, according to the weighting factors w_x and w_y, for criteria x and y respectively, the maximum values of the reference are multiplied yielding the best point ($p_{\max}$)

$$p_{max} = (w_x x_{max}, w_y y_{max}). \qquad (9)$$

The best point is the maximum value that can obtain from AHP. Consequently, we can assume that if any of alternative can locate closest or equal to this point, it must be the best choice for the AHP. The vector from the point p_a, which is preference value multiplied with weights factors, to best point ($p_{\max}$) is determined as

$$(\vec{d}_a) = p_{max} - p_a, \qquad (10)$$

$$= (w_x x_{max} - w_x x_a, w_y y_{max} - w_y y_a), \qquad (11)$$

$$= (d_x, d_y) \qquad (12)$$

where d_x and d_y represent the different in x and y axis, respectively. The magnitude of vector is the distance between the two points which is equal to

$$|\vec{d}_a| = \sqrt{d_x^2 + d_y^2}. \qquad (13)$$

Similar to the previously described process, the distance between each preference of alternative j^{th} to the best point of the N criteria can be obtained as follows:

$$|\vec{d}_j| = \sqrt{\textstyle\sum_{i=1}^{N} d_{i,j}^2}. \qquad (14)$$

The best alternative according to the VAM (denoted by $A_{\text{bst,vam}}$) must be the one that gives the minimum distance, i.e.,

$$A_{\text{bst,vam}} = \min\{|\vec{d}_j|\} \quad \text{for } j = 1,2, \ldots \text{M}, \qquad (15)$$

where min{.} is denoted the minimum notation.

To verify this idea, the scalar and vector computations of the alternative score are compared and see the reflection on the relative priority score in final.

Research Methodology

1. Research Design

This investigation focuses on the selection and evaluation of suppliers. An invitation letter to participate in this study was sent to the company which will be the case study for this research. The process of the research will be achieved through three main phase as shown in Figure 3. The first phase is identifying the sample vendors and some major criteria that should be considered. In addition, data will be gathered through available literature on vendor selection and working teams for vendor selection.

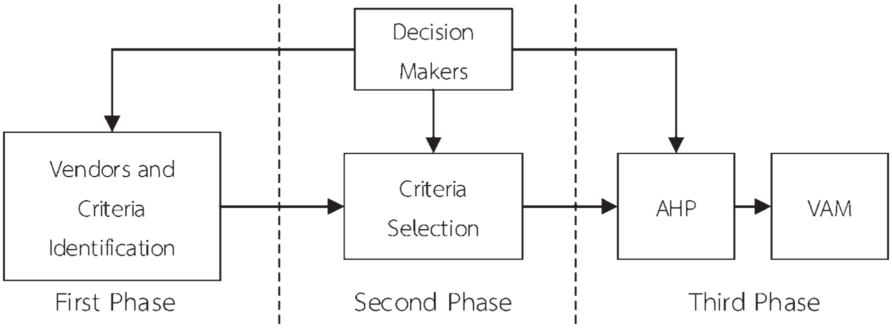

Figure 3 Research design framework

The second phase is the selecting criteria, which were screened and identified in phase one to be used as an initial formulating a questionnaire. The questionnaire would be responded by the decision makers who are directly involved in the vendor selection project. They were asked to rate the selected criteria in importance order.

The last phase is the implementation of the selected vendor using AHP as a decision analysis tool and the result comparing with the measuring in weighted using VAM in final stage.

2. Preliminary Study

2.1 Data Collection

The data used in this study are mainly collected through the questionnaire of pairwise comparison to compare each pair of the criterion used in the vendor selection. The developed questionnaires were administered to the people whom the decision analysis is referred such as vendor selection working team.

2.2 Research Population

The vendor selection is discussed in this work for a company which needs a suitable vendor for a project. The company used in this study is an IT company, which has a high growth rate in the last 5 years with 300 employees. Questionnaires were sent to the targeted vendors which are currently deal with the company.

2.3 Criteria Validation

According to the criteria which are normally used in the vendor or supplier selection, the criteria list was compiled from the previous studies of De Boer & Van Der Wegen (2003) and Weber & Ellram (1993). We also have face-to-face interviews with vendor selection working team to ensure that all chosen criteria used in this study are satisfied and suitable for the company.

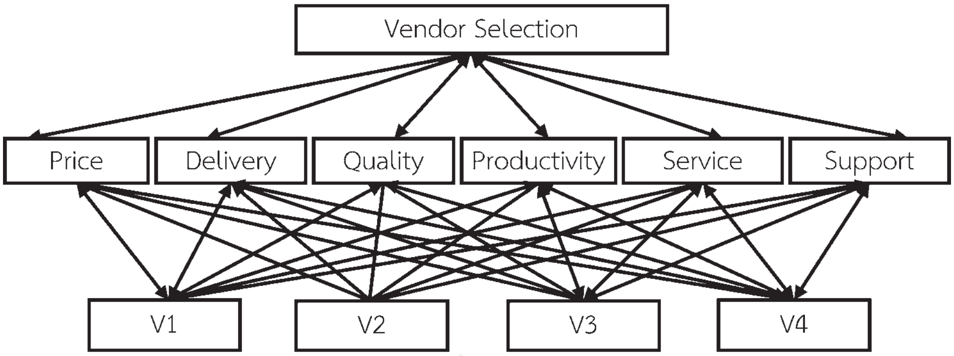

Figure 4 A hierarchical representation of the vendor selection model

2.4 Questionnaire Design

The questionnaires were designed in English and submitted to the decision makers with a cover letter explaining the purpose of the work, introduction of criteria, the pairwise comparison of all selected criteria, and the way of responding.

Implementation and Results

This section shows the implementation and results of the proposed technique. The evaluation is performed in the real world business case. The details of the implemen-tation and results are shown as follows:

1. Criteria for Vendor Selection

In this work, the required data were collected and rated based on the interview which was performed by four members of project steering committee, comprising of two project managers, one functional manager, and one project sponsor. The list of criteria in the interview was chosen from the previous works (Weber & Ellram, 1993). Six important criteria for a general project of the company that was selected are price, delivery, quality, productivity, service, and support.

2. Prospective Vendors

The next step for vendor selection process is to list the candidates of vendors that are available for alternative selection. In this research, we obtained the list of 4 vendors after the pre-filtering process by project steering committee.

3. AHP Model of Vendor Selection

The developed AHP model for our work contains three levels, given as the goal, the criteria, and the alternative vendors. The first level of the hierarchy is identified to select the vendor. The second level (criteria) contains price, delivery, quality, productivity, service, and support. The third level of the hierarchy contains the alternative vendors to be evaluated for the best vendor selection as shown in Figure 4, where V1, V2, V3, and V4 represent vendor 1, vendor 2, vendor 3 and vendor 4, respectively.

Table 2 Pairwise comparison matrix of the criteria

	Price	Delivery	Quality	Productivity	Service	Support	Weight
Price	1.00	1.00	3.00	7.00	6.00	5.00	0.3480
Delivery	1.00	1.00	3.00	6.00	5.00	4.00	0.3190
Quality	0.33	0.33	1.00	4.00	3.00	3.00	0.1540
Productivity	0.14	0.17	0.25	1.00	0.50	0.50	0.0413
Service	0.17	0.20	0.33	2.00	1.00	0.50	0.0587
Support	0.20	0.25	0.33	2.00	2.00	1.00	0.0790

4. Criteria Pairwise Comparison

After proposing the hierarchy, pairwise comparisons were used to compare according to their relative importance of criteria rated by the nine-point scale. The questionnaires were distributed to 4 respondents from project steering committee. Table 2 shows the pairwise comparison matrix of six main criteria. From the first row of Table 2, we can see that the relative importance of delivery and price are equal so the given scale of this comparison is 1, the relative importance value of quality and price is 3, the relative importance value of productivity and price is 7, and so on. The similar explanation of the row one can be used to describe the other rows of Table 2.

The next step is to adjust the values measured on a common scale. The calculation was done by divisions between the vector data in the vertical column and its summation in vector column as shown in (16).

$$x_{i,j} = \frac{a_{i,j}}{\sum_{i=1}^{N} a_{i,j}}. \qquad (16)$$

Then set weight or prioritized each criterion by determining the right principal eigenvector (Saaty, 1980). It could be obtained by averaging across the rows as shown in (17).

$$w_{i,j} = \frac{\sum_{i=1}^{N} x_{i,j}}{N} \qquad (16)$$

The result of the weighting criteria list was arranged in Table 2.

The next step is to calculate CR to determine the acceptance of the priority weighting as equation (2). For the result of CR for this work is 0.02, as CR value is much less than 0.1, the pairwise comparison evaluations are consistent, and thus are acceptable.

5. Vendor pairwise comparison

As same as the pairwise comparison of the criteria, the respondents were asked to compare each pair of four vendors with respect to each criterion. Tables 3-8 show the pairwise matrix and priority weights.

6. Overall Ratings with WSM

After finding out the answer from the matrix of pairwise comparisons of all vendors, the next process is to find out which vendor is the most appropriate for this project by applying the weights of all criteria from Table 2 to the weights of all vendors. This step consists of multiplying the weight of each criterion with the priorities weight of vendor and then sum up to find out the final ranking of the vendors as shown in Table 9.

Table 3 Pairwise comparison matrix of vendors with respect to price

	V1	V2	V3	V4	Weights
V1	1.00	5.00	4.00	2.00	0.4790
V2	0.20	1.00	0.33	0.20	0.0676
V3	0.25	3.00	1.00	0.33	0.1392
V4	0.50	5.00	3.00	1.00	0.3141

Table 4 Pairwise comparison matrix of vendors with respect to delivery

	V1	V2	V3	V4	Weights
V1	1.00	8.00	6.00	2.00	0.5224
V2	0.13	1.00	1.00	0.20	0.0657
V3	0.17	1.00	1.00	0.14	0.0673
V4	0.50	5.00	7.00	1.00	0.3446

Table 5 Pairwise comparison matrix of vendors with respect to quality

	V1	V2	V3	V4	Weights
V1	1.00	1.00	0.20	0.17	0.0843
V2	1.00	1.00	0.50	0.25	0.1099
V3	5.00	2.00	1.00	0.25	0.2400
V4	6.00	4.00	4.00	1.00	0.5658

Table 6 Pairwise comparison matrix of vendors with respect to productivity

	V1	V2	V3	V4	Weights
V1	1.00	2.00	1.00	0.50	0.2124
V2	0.50	1.00	2.00	0.25	0.1437
V3	1.00	0.50	1.00	0.17	0.1190
V4	2.00	4.00	6.00	1.00	0.5249

Table 7 Pairwise comparison matrix of vendors with respect to service

	V1	V2	V3	V4	Weights
V1	1.00	0.20	0.33	2.00	0.1244
V2	5.00	1.00	2.00	5.00	0.5186
V3	3.00	0.50	1.00	2.00	0.2600
V4	0.50	0.20	0.50	1.00	0.0971

Table 8 Pairwise comparison matrix of vendors with respect to support

	V1	V2	V3	V4	Weights
V1	1.00	0.25	0.20	0.20	0.0651
V2	4.00	1.00	1.00	0.50	0.2299
V3	5.00	1.00	1.00	0.25	0.2145
V4	5.00	2.00	4.00	1.00	0.4905

Table 9 Final ranking of vendors by using AHP with WSM

	Score	Rank
V1	0.3675	2
V2	0.1160	4
V3	0.1440	3
V4	0.3725	1

Table 10 Final ranking of vendors by using AHP with VAM

	Score	Rank
V1	0.0851	1
V2	0.2186	4
V3	0.1990	3
V4	0.1100	2

7. Overall Ratings with VAM

After all the steps were finished and the evaluated ranking of vendors from the hierarchy process was completed, the calculations can be compared by using vector analysis. According to (9), we can get the best point according to each criterion as follows:

$$P_{max} = (1\times0.3480,\ 1\times0.3190,\ 1\times0.1540,\ 1\times0.0413,\ 1\times0.0587,\ 1\times0.0790) \quad (18)$$

$$= (0.3480,\ 0.3190,\ 0.1540,\ 0.0413,\ 0.0587,\ 0.0790). \quad (19)$$

To find out which vendor is the most appropriate for this project, the process can be done by applying the VAM from (10) (14) and (19). The final ranking of the vendors is shown in Table 10.

The vendor with the minimum distance to the best point is the best alternative that should be selected. According to the results presented in Table 10, we can see that the Vendor 1 is the best vendor among all vendors in this case.

Result Evaluation and Discussion

The result of final ranking scores of vendors using vector analysis is quite similar to the result of AHP where the Vendor 1 and Vendor 2 are the top two ranks as presented in Tables 9 and 10. Notice that the value of score result from WSM is very close to the score ranking no.1 (Vendor 4) and no.2 (Vendor 1).

From Table 10, we can see that the scores of Vendor 1 and Vendor 2 obtained from AHP with VAM give more different value than the result obtained from AHP with WSM as shown in Table 9. According to (15), Vendor 1 should be the selected one. The ranking results presented in Tables 9 and 10 would be a decision support for the project team in case of selecting vendors. The final step in this work is to confirm the proposed technique by evaluating the consistency ranking and stakeholder satisfaction.

In order to confirm benchmark of this work, the project steering committee has to input the score of the four vendors and prioritize the weight of six criteria. This method was referred to the decision matrix (DM), the existing method in this company. The result is shown in Table 11. Then, the result is compared with the ranking result of the framework as shown in Tables 9 and 10. The obtained results are given in Table 12, where DM is denoted the decision matrix technique.

Note that the decision matrix technique is a simple technique of MCDM which is suitable for a problem that all criteria are expressed in term of the same unit (Triantaphyllou & Mann, 1995). The company used this technique because of the convenience of implantation and computation. However, giving the score of a criterion among other criteria might be a complex problem and easy to create an improper score when the criteria are in different domains or units. For this company, each member of the steering committee has been well experienced with decision matrix technique that can be able to give a reasonable score for criteria and vendors. Therefore, this technique is used for comparison with the conventional AHP and the proposed AHP.

Table 11 Vendor selection using decision matrix

Criterion	Weight	Score				Weighted Score			
		V1	V2	V3	V4	V1	V2	V3	V4
Price	30.00	0.90	0.50	0.50	1.00	27.00	15.00	15.00	30.00
Delivery	25.00	1.00	0.40	0.50	0.80	25.00	10.00	12.50	20.00
Quality	25.00	1.00	0.50	0.50	0.80	25.00	12.50	12.50	20.00
Productivity	10.00	0.30	0.70	0.40	0.50	3.00	7.00	4.00	5.00
Service	5.00	0.80	0.40	0.40	0.60	4.00	2.00	2.00	3.00
Support	5.00	1.00	0.40	0.50	0.70	5.00	2.00	2.50	3.50
					Total	89.00	48.50	48.50	81.50

Table 12 Ranking result from proposed technique and exiting process

	WSM	VAM	DM
V1	2	1	1
V2	4	4	3
V3	3	3	3
V4	1	2	2

From the result in Table 12, we found that the decision matrix was ranked close to the rank of vector analysis. It also shows that only rank of the vendor 2 had a different result.

Finally, the results from these techniques were taken into consideration with the expert who is the team leader of the steering committee. The expert agreed that the result from the proposed technique is more similar to the result from the decision matrix technique than the result from the conventional AHP. Without these methods, comparing Vendor 1 to Vendor 4, the expert preferred to select the Vendor 1 with proposed technique and decision matrix technique.

From the overall process of the AHP technique presented in this work, we can see that this technique is more complicated than the existing technique, DM technique, on both perspectives, i.e., implementation and computation. However, as described in the previous section, the scoring of each criterion among other criteria with different units can become a complex task. Therefore, a system that can easily give the score of the criteria or the alternatives is necessary for this situation, therefore, the AHP is the best solution. However, the last step of AHP which is the summation of the score according to criteria in different unit should be improved by using VAM as described in this work. The implementation and computation complexity can be improved by using a dedicated computer software.

As presented in this article, the uses of the proposed technique is demonstrated by using the vendor selection problem as a case study. The similar procedure can be applied to other case studies. Nevertheless, the comparison of the proposed system with the conventional AHP can be clearly presented by using the mathematical analysis, which could be the further work.

Conclusions

Selection of the right vendor is an important task. Many techniques are provided for this function. In this work, an improvement of AHP with vector analysis is proposed. The proposed technique was evaluated by using a case study of a company. The evaluation model based on six criteria which are price, quality, delivery, productivity, service, and support was applied to four candidate vendors. The conventional techniques, including AHP with WSM, and decision matrix technique, are used to compare with the proposed technique. The experimental results showed that the result from decision matrix technique was similar to the result of the proposed technique, while the rankings result of conventional AHP is different. The results were confirmed by the expert with the conclusion that the result from the proposed technique and decision matrix technique is more reasonable than the result from the conventional AHP.

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