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An integrated MCDM technique combined with DEMATEL for a novel cluster-weighted with ANP method

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1. Introduction

Over the past two decades, numerous studies have been made on multiple criteria decision making (MCDM) analysis in various fields. Basically, the multiple criteria decision issue focuses mainly on distinguishing the evaluation criteria and on the determining the preference structure (i.e., weights). Since the results of evaluating and comparing alternatives are based on decision-makers' preference, the determination of preference structures is very important during the decision making process. If the criterion importance can be captured properly, the quality of decision making will be enhanced correspondingly. Conventionally, when importance-assessing methods are used to demonstrate the criterion importance, the manner of multi-criteria decision analysis is often based on the assumptions of additivity and independency. However, people have found that using such traditional methods (i.e., additive model) is not always proper because of the dependence and feedback among the criteria to somewhat different degrees. To solve the issue, analytic network process (ANP) was proposed in Saaty (Saaty, 1996, 2004; Saaty and Vargas, 1998) to overcome the problem of dependence and feedback among criteria or alternatives. The ANP is the general form of the analytic hierarchy process (AHP) (Saaty, 1980), which has been used for MCDM, to release the restriction of hierarchical structure, and has been applied to project selection (Lee & Kim, 2000; Meade & Presley, 2002), product planning, strategic decision (Karsak, Sozer, & Alptekin, 2003; Lin, Chiu, & Tsai, 2008; Sarkis, 2003), optimal scheduling (Momoh & Zhu, 2003) and strategic decision (Leung, Lam, & Cao, 2006; Wu & Lee, 2007a, 2007b). Lee and Kim (2000, 2001) used ANP to facilitate an information system project selection problem but made it more complicated due to the need to consider the interdependencies among criteria and candidate projects. ANP was also used successfully for the selection of various project alternatives in an agile manufacturing process.

However, in ANP procedures, the first phase of the ANP is to compare the criteria in whole system to form the unweighted supermatrix. The decision-maker is asked to answer the question like “How much importance does a criterion have compared to

Traditionally, most importance-assessing methods used to demonstrate the importance among criteria by preference weightings are based on the assumptions of additivity and independence. In fact, people have found that using such an additive model is not always feasible because of the dependence and feedback among the criteria to somewhat different degrees. To solve the issue, the analytic network process (ANP) method is proposed by Saaty. The general method is easy and useful for solving the above-mentioned problem. However in ANP procedures, using average method (equal cluster-weighted) to obtain the weighted supermatrix seems to be irrational because there are different degrees of influence among the criteria. Therefore, we intended to propose an integrated multiple criteria decision making (MCDM) techniques which combined with the decision making trial and evaluation laboratory (DEMATEL) and a novel cluster-weighted with ANP method in this paper, in which the DEMATEL method is used to visualize the structure of complicated causal relationships between criteria of a system and obtain the influence level of these criteria. And, then adopt these influence level values as the base of normalization supermatrix for calculating ANP weights to obtain the relative importance. Additionally, an empirical study is illustrated to demonstrate that the proposed method is more suitable and reasonable. By the concept of ideal point, some important conclusions drawn from a practical application can be referred by practitioners.

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ABSTRACT

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another criterion with respect to our interests or preferences?"
After forming the supermatrix, the weighted supermatrix is
derived by transforming all columns sum to unity exactly (i.e.,
using average method). Next, the weighted supermatrix is raised
to limiting powers to get the global priorities or called weights. It
seems to be irrational while the weighted supermatrix is obtained
by using average method. Because there are have different influ-
ence levels among criteria based on network relationship map
(NRM). If we utilize the average method (equal cluster-weighted)
to calculate the final global priorities, the results of the assessed
weights would be higher or lower than the real situation. To this
der, the decision making trial and evaluation laboratory (DEMA-
TEL) method (Fontela & Gabus, 1976) is introduced to build
the structure of relationship map for clarifying the interrelations
among sub-criteria of a criterion, as well as to visualize the causal
relationship of sub-systems through a causal diagram. The original
DEMATEL was aim at searching the fragmented and antagonistic
phenomena of world societies for integrated solutions. In recent
years, the DEMATEL method has become very popular in Japan be-
cause it is especially pragmatic to visualize the structure of compi-
cated causal relationships. The diagraph portrays a basic concept of
textual relationship among the criteria of the system, in which the
numerical represents the strength of influence. The method has been
successfully applied to various circumstances, for example, devel-
oping global managers’ competencies (Wu & Lee, 2007a, 2007b),
evaluating intertwined effects in e-learning programs (Tzeng,
Chiang, & Li, 2007), airline safety measurement (Liou, Tzeng, &
Chang, 2007), innovation policy portfolios for SIP mall industry
(Huang & Tzeng, 2007), choice of knowledge management strategy
(Wu, 2008), causal analytic method for group decision making (Lin
& Wu, 2008), and selection management systems of SMEs (Tsai &
Chou, 2009).
Therefore, in this paper an integrated MCDM technique com-
bined DEMATEL and ANP methods is proposed to solve this prob-
lem for overcoming the problem of interdependence and
feedback between criteria and alternatives. Also, this study uses
the DEMATEL method to obtain the influence degree of these crite-
ria, and it would be regarded as the basis of normalization
supermatrix for calculating ANP weights to obtain the relative
importance. In addition, an empirical study is illustrated to demon-
strate that the proposed method is more suitable. Furthermore, we
employ the concept of ideal-point by setting desired/desired levels
to represent the gaps between the performance of the appropriate
vendor and the desiring/desired levels of each criterion.
The remainder of this paper is organized as follows. In Section 2,
we describe the concepts of DEMATEL and ANP methods in the
proposed method. An empirical study is illustrated to demonstrate
the proposed method is useful and suitable, and the results are ad-
dressed in Section 3. Discussions are presented in Section 4, and
conclusions are presented in the last section.

2. Integrated methods combined DEMATEL and ANP
In this section, an integrated method, combined DEMATEL
method, and a novel cluster-weighted ANP method is developed.
The procedures that are used in the proposed method are de-
scribed as follows.

2.1. The DEMATEL method
The DEMATEL method is based upon graph theory, enabling us
to plan and solve problems visually, so that we may divide mul-
ple criteria into a cause-and-effect group, to better understand
causal relationships to plot a network relationship map. Directed
graphs (also called digraphs) are more useful than directionless
graphs, because digraphs will demonstrate the directed relation-
ships of sub-systems. A digraph may typically represent a commu-
nication network, or some domination relationships between
individuals. The methodology can confirm interdependence among
variables/criteria and restrict the relations that reflect characteris-
tics within an essential systemic and developmental trend (Chiu,
Chen, Tzeng, & Shyu, 2006; Hori & Shimizu, 1999; Tamura, Nagata,
&Akazawa, 2002). The end product of the DEMATEL process is a vi-
sual representation by which the respondent organizes his or her
action in the world (Tzeng et al., 2007), e-learning evaluation
(Tzeng et al., 2007), airline safety measurement (Liou et al.,
2007), and innovation policy portfolios for Taiwan’s SIP Mall
(Huang & Tzeng, 2007).
The DEMATEL method can be summarized in the following steps:
Step 1: Find the average matrix. Suppose we have H experts in
this study and n criteria to consider. Each expert is asked to indi-
cate the degree which represents he or she believes a criterion i a-
flicts criterion j. These pairwise comparisons between any two
criteria are denoted by $a_{ij}$ and are given an integer score ranging
from 0, 1, 2, 3, and 4, representing ‘No influence (0),’ ‘Low influence
(1),’ ‘Medium influence (2),’ ‘High influence (3),’ and ‘Very high
influence (4),’ respectively. The scores by each expert will give us
a $n \times n$ non-negative answer matrix $X^{n,n} = [a_{ij}]_{ln,n}$, with $1 \leq k \leq H$.
Thus, $X_k^{n,n},X_2^{n,n},...,X_H^{n,n}$ are the answer matrices for each of the H
experts, and each element of $X_k$ is an integer denoted by $a_{ij}^{k}$. The diag-
onal elements of each answer matrix $X_k$ are all set to zero. We can
then compute the $n \times n$ average matrix $A$ for all expert opinions by
averaging the H experts’ scores as follows:

$$a_{ij}^{n,n} = \frac{1}{H} \sum_{k=1}^{H} a_{ij}^{k,n,n}$$ (1)

The average matrix $A = [a_{ij}^{n,n}]$ is also called the initial direct relation
matrix. $A$ shows the initial direct effects that a criterion exerts on
and receives from other criteria. Furthermore, we can map out the
causal effect between each pair of criteria in a system by drawing
an influence map (If $a_{ij}^{k} < 1$ for all i, j, we can identify among all criteria
are independent; otherwise, we can identify all criteria are non-
independent). Fig. 1 below is an example of such a network influence
map. Each letter represents a criterion in the system. An arrow from
j to i shows the effect that criterion i has on criterion j, and the strength of its effect
is. DEMATEL can convert the structural relations among the criteria
of a system into an intelligible map of the system.

Step 2: Calculate the normalized initial direct-relation matrix. The
normalized initial direct-relation matrix $D$ is obtained by normal-
izing the average matrix $A$ in the following way:

$$D = \frac{A}{\text{trace}(A)}$$

Fig. 1. Example of an influence map.
Let $s = \max \left( \frac{1}{n} \sum_{i=1}^{n} a_{ii}, \frac{1}{n} \sum_{j=1}^{n} a_{jj} \right)$, \( n \geq 2 \).

Then $D = A^s$.

Since the sum of each row $i$ of matrix $A$ represents the total direct effects that criterion $i$ gives to the other criteria, $\frac{1}{n} \sum_{j=1}^{n} a_{ij}$ represents the total direct effects of criterion $i$ to criteria $j$. Likewise, the sum of each column $j$ of matrix $A$ represents the total direct effects of the criterion with the most direct effects on criteria $i$. The total direct effects that the criterion $j$ receives the most direct effects from other criteria. The positive scalar $s$ takes the smaller of the two as the upper bound, and the matrix $D$ is obtained by dividing each element of $A$ by the scalar $s$. Note that each element $d_{ij}$ of matrix $D$ is between zero and less than one.

Step 3: Compute the total relation matrix. A continuous decrease of the indirect effects of problems along the powers of matrix $D$, e.g. $D^2, D^3, \ldots, D^n$, guarantees convergent solutions to the matrix inverse similar to an absorbing Markov chain matrix. Note that $\lim D^0 = (I - D)^{-1}$ and $\lim (I \times D + D^2 + D^3 + \ldots + D^n) = (I - D)^{-1}$, where $I$ is the $n \times n$ identity matrix. The total relation matrix $T$ is an $n \times n$ matrix and is defined as follows:

$$T = [t_{ij}], \ i, j = 1, 2, \ldots, n$$

where

$$T = D + D^2 + \ldots + D^n = (I + D + D^2 + \ldots + D^n - I) = (I - D)^{-1} = (I - D)^{-1}$$

Step 2. The ANP method

The ANP is an extension of AHP, and it is the general form of analytic hierarchy process (AHP). The ANP handles dependence within a criterion (inner dependence) and among different criteria (outer dependence). AHP models a decision-making framework using a unidirectional hierarchical relationship among criteria, but ANP allows more complex interrelationships among criteria. A major difference between the two techniques is the existence of a feedback relationship among criteria within this framework.

The method of the ANP can be described as follows. The first step of the ANP is to compare the criteria in whole system to form the supermatrix. This is done through pairwise comparisons by asking “How much importance/influence does a criterion have compared to another criterion with respect to our interests or preferences?” The relative importance value can be determined using a scale of 1–9 to represent equal importance to extreme importance (Saaty, 1980, 1996). The general form of the supermatrix can be described as follows:

$$T = C_1 C_2 C_3 \ldots C_n$$

where $s$ denotes transpose.

Let $t_{ij} = \sum_{i=1}^{n} a_{ij}$ be the sum of $i$th row in matrix $T$. Then $r_i$ shows the total effects, both direct and indirect, given by criterion $i$ to the other criteria $j = 1, 2, \ldots, n$. Let $c_i = \sum_{j=1}^{n} a_{ij}$ denotes the sum of $j$th column in matrix $T$. Then $c_j$ shows the total effects, both direct and indirect, received by criterion $j$ from the other criteria $i = 1, 2, \ldots, n$. Thus when $j = i$, the sum $c_i$ gives us an index representing the total effects both given and received by criterion $i$. In other words, $r_i$ shows the degree of importance (total sum of effects given and received) that criterion $i$ plays in the system. In addition, the difference $(r_i - c_i)$ shows the net effect that criterion $i$ contributes to the system. When $(r_i - c_i)$ is positive, criterion $i$ is a net causer, and when $(r_i - c_i)$ is negative, criterion $i$ is a net receiver (Tamura et al., 2002; Tzeng et al., 2007).

Step 4: Set a threshold value and obtain the network relationship map (NRM). In order to explain the structural relation among the criteria and keep the complexity of the system to a manageable level at the same time, it is necessary to set a threshold value $p$ to filter out some negligible effects in matrix $T$. Only some criteria, whose effect in matrix $T$ is greater than the threshold value, should be chosen and shown in a network relationship map (NRM) for influence (Tzeng et al., 2007).

In this paper, the threshold value has been decided by experts through discussions. After the threshold value is decided, the final influence result of criteria can be shown in a NRM. To clearly represent the procedures of the DEMATEL method, a simple example is developed to show how the NRM can be obtained and as well as how the relationships of criteria discussed above can be determined. For example, suppose a system contains three criteria $C_1$, $C_2$ and $C_3$, the total-influence matrix $T$ can be derived by running from step 1 to step 4. Next, based on the threshold value $p$, we can filter the minor effects in the elements of matrix $T$. The values of elements in matrix $T$ are zero if their values less than $p$. That is, there are lower influences with other criteria when their values are less than $p$. Thus, a new total-influence matrix $T_p$ can be obtained and the NRM can also be shown as Fig. 2 below.
where $C_n$ denotes the $n$th cluster, $e_{mn}$ denotes the $m$th element in $n$th cluster, and $W_t$ is the principal eigenvector of the influence of the elements compared in the $j$th cluster to the $i$th cluster. In addition, if the $j$th cluster has no influence to the $i$th cluster, then $W_t = [0]$. After, the weighted supermatrix is obtained by multiplying the total-influence matrix, which is derived according to DEMATEL method. Traditionally, the weighted supermatrix is derived by transforming all columns sum to unity exactly. This step is much similar to the concept of Markov chain which ensures the sum of these probabilities of all states equals to 1. However, we know each criteria’s affect the other criteria may be different according to the results of the DEMATEL method. If the influence degrees of these criteria are regarded as equal, that is, using average method to obtain the weighted supermatrix. The results of the assessed weights would be higher or lower than the real situation. It would be irrational and unsuitable in real situation. For this reason, we intend to adopt the DEMATEL method to overcome the shortcomings, and to suppose that the total-influence matrix $T_p$ has been determined according to the DEMATEL method result. Because the influence degrees between criteria in the total-influence matrix $T_p$ are different, all criteria of the total-influence matrix $T_p$ should be normalized. The normalized elements of the total-influence matrix $T_p$ are $t_{ij} = \frac{e_{ij}}{\sum_{j=1}^{n} e_{ij}}$ and the normalized total-influence matrix $T_z$ is represented as follows:

$$T_z = \begin{bmatrix}
t_{11} & \cdots & t_{ij} & \cdots & t_{1n} \\
\vdots & \ddots & \vdots & \ddots & \vdots \\
t_{1n} & \cdots & t_{jn} & \cdots & t_{nn}
\end{bmatrix}$$

Furthermore, the weighted supermatrix $W_t$ such as Eq. (9) can be calculated by multiplying the unweighted supermatrix $W$ and the normalized total-influence matrix $T_z$. That is $W_t = T_z \times W$ (9)

Finally, we raise the weighted supermatrix to limiting powers $l$ such as Eq. (10) until the supermatrix converged to get the global priority vectors or weights.

$$\lim_{l \to \infty} W_t = \frac{1}{1} (\sum_{j=1}^{n} W_t^j)$$

where $W_t$ denoted the $l$th limiting supermatrix.

### 3.3. Problems descriptions

The case company is a well-known 3C component manufacturer in Taiwan. Its products mainly include PC enclosures, communications equipment, and consumer electronic products. In 2004, the consolidated revenues were US$13 billion dollars, and the company has over 100,000 employees around the world. Its main customer groups include a lot of global enterprises, such as Intel, IBM, Dell, HP, Motorola, and Sony. For this case company, decision maker has only considered several important criteria for selecting an appropriate vendor in a purchase project. But in real situations, the appropriate vendor may find that the performances on specific criteria are poor in procurement manager’s mind. To find out the central criteria for improving the performance of an appropriate and best vendor in the complex system, an effective vendor selection model based on the relations map among criteria is needed. According to the purchasing request (e.g., 10,000 pieces/week) of heat sinks based on scenario writings and brainstorming for notebook personnel computer in a consumer electronic business division, we will evaluate and improve these five candidate vendors ($V_1$, $V_2$, $V_3$, $V_4$, and $V_5$). Those vendors who successfully passed the screening processes were eligible for procurement. Also, choosing the possible evaluation criteria for the vendor improvement and selection involves a decision making team, which includes managers from different functional divisions of the case company (i.e., purchasing director, purchasing manager, quality manager, product manager and production manager). The criteria and sub-criteria involved in the vendor selection have been chosen according to the expertise of professional knowledge and managers’ experiences. These major influencing criteria and sub-criteria involved in vendor selection are given in Table 1. Then, a purchasing committee with five experts $E_1$, $E_2$, $E_3$, $E_4$, and $E_5$ is constituted to determine the network relationships and weights among criteria. And give the performance scores for each candidate vendor in terms of all criteria in the evaluation hierarchical structure respectively. The following shows how the case company utilized our proposed method to evaluate and select the best vendor when these criteria with interdependence on each other.

### 3.2. Determining the network relationships among criteria

The aim of the phase is to determine the network relationships among criteria in influence each other. A questionnaire was used to find out influential relations from each expert for ranking each criterion on the appropriate vendor with a four-point scale ranging from 0 to 4, representing from ‘No influence (0)’ to ‘Very high influence (4),’ respectively. Meanwhile, the participants are also asked to respond to a questionnaire through a series of pairwise compari-

### Table 1: Criteria and sub-criteria for the vendor selection

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-criteria</th>
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<tbody>
<tr>
<td>Quality ($C_1$)</td>
<td>Quality performance ($C_{11}$)</td>
</tr>
<tr>
<td>Quality ($C_1$)</td>
<td>Quality containment &amp; VDCS feedback ($C_{12}$)</td>
</tr>
<tr>
<td>Price &amp; Terms ($C_2$)</td>
<td>Price ($C_{21}$)</td>
</tr>
<tr>
<td>Price &amp; Terms ($C_2$)</td>
<td>Terms ($C_{22}$)</td>
</tr>
<tr>
<td>Price &amp; Terms ($C_2$)</td>
<td>Responsiveness ($C_{23}$)</td>
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<tr>
<td>Price &amp; Terms ($C_2$)</td>
<td>Lead time ($C_{24}$)</td>
</tr>
<tr>
<td>Price &amp; Terms ($C_2$)</td>
<td>VMX/VMI hub set up cost ($C_{25}$)</td>
</tr>
<tr>
<td>Supply chain support ($C_3$)</td>
<td>Purchase order reactiveness ($C_{31}$)</td>
</tr>
<tr>
<td>Supply chain support ($C_3$)</td>
<td>Capacity support &amp; flexibility ($C_{32}$)</td>
</tr>
<tr>
<td>Supply chain support ($C_3$)</td>
<td>Delivery/VMI operation ($C_{33}$)</td>
</tr>
<tr>
<td>Technology ($C_4$)</td>
<td>Technical support ($C_{41}$)</td>
</tr>
<tr>
<td>Technology ($C_4$)</td>
<td>Design involvement ($C_{42}$)</td>
</tr>
<tr>
<td>Technology ($C_4$)</td>
<td>ECN/PCN process ($C_{43}$)</td>
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</table>
sons with Saaty's nine-point scale. This questionnaire was developed based on the pairwise comparison, in which each question consisted of a pairwise comparison of two criteria. For each pairwise comparison, the participants have to determine the intensity of the relative importance between two criteria. At first, the average initial direct matrix \( A \) is obtained based on Eq. (1) as Table 2. By using Eqs. (2) and (3), the normalized initial direct-relation matrix \( D \) is calculated. Sequentially, the total relation matrix \( T \) is also derived utilizing Eq. (4) shown in Table 3. Total sum of effects given and received by each criterion is seen in Table 4 using Eqs. (5) and (6). To obtain an appropriate network relationship map (NRM), a threshold value of 0.7 was chosen by experts. Thus the NRM of DEMATEL method result was obtained and shown in Fig. 3.

### 3.3. Calculating the weights of criteria

From Table 3, we know the degrees of influence of criteria are different with each other. The cluster-weighted supermatrix that was obtained by using traditional average method (equal cluster-weighted) in ANP is irrational. Therefore, the normalized matrix \( T_z \), which is obtained influential cluster-weighted by DEMATEL method results, is combined to the procedure of the ANP method in this study. At first, the total influence matrix is normalized by using Eq. (8) shown as Table 5. Based on the NRM of influential relations, the importance of relationships between sub-criteria is compared. An unweighted supermatrix can be obtained by using Eq. (7) as Table 6. By applying Eq. (9), the weighted supermatrix is determined and its result is expressed in Table 7. By calculating the limiting power of the influential cluster-weighted supermatrix, Eq. (10) is applied until a steady-state condition has been achieved. Finally, the weights of each sub-criterion can be obtained. To further compare the difference of traditional ANP method and our proposed method, we calculate the limiting supermatrix with traditional average method, and the influential cluster-weighted supermatrix is derived shown in Table 8. As seen in Tables 7 and 8, the ranks of weights for each sub-criterion by two methods are different.

On the other hand, for each candidate vendor, five experts are asked to evaluate the level of satisfactions for each criterion. The normalized performance score \([0, 1]\) for the candidate vendors is shown in Table 9. Using the performance data of each candidate vendor (Table 9), the synthesis score of the proposed method, unlike the traditional average method, conducts with normalized problem in ANP process (Table 9 below). Regardless of using the traditional average method or the proposed method, the ranking of the candidate vendors will be same. That is, the appropriate vendor is \( V_z \). Furthermore, we employed the concept of the ideal point to represent the results of the analysis for selecting appropriate vendor with the proposed method in Fig. 4. These aspiring/ideal points (1 scores) represent points at which all criteria of each vendor would be optimized. It emphasizes the gaps between the appropriate vendor and the ideal points. We could find that there is still a great deal of room for these candidate vendors to drastically improve their performance.

### 4. Discussions

Based on the results in above Section 3, those criteria had some interrelations with each other. The direct/indirect influential relationship of criteria was figured out by using the DEMATEL method. According to the impact-direction map (Fig. 5), we can obtain valuable cues for making accurate decisions. At first, we know the influence degrees among criteria are different based on the impact-direction map. Since decision-maker can find the key criterion for improving the performances of vendors. It is clear for a purchase department to find the exact vendor's performance. For example, if the case company wanted to improve the effectiveness of a specific criterion (e.g., Supply chain support \( C_3 \)), it would possible be necessary to pay greatly attention to the Quality \( C_1 \) and Price \& Terms \( C_2 \) criteria. This is because the Quality and Price \& Terms criteria are the influencing criteria, whereas the supply chain support criterion is the influenced criterion. Then, it is easier for a company to find the performance of the appropriate vendor by...
term criterion is affected by Supply chain support criterion. It rep-

criterion is 1.126 (see Table 3). Obviously, Supply chain support

and Technology in the traditional average method are higher than

Price & Terms in the traditional average method are lower than

obtained shown as Fig. 6. In Fig. 6, the sub-criteria of Quality and

using the results. Additionally, it can be provided to derive the

influential cluster-weighted supermatrix to obtain the weights of

criteria in ANP method. The ranking results of weights of sub-crite-

ria between the traditional average method and the DEMATEL

method which normalizing the unweighted supermatrix can be

obtained shown as Fig. 6. In Fig. 6, the sub-criteria of Quality and

Price & Terms in the traditional average method are lower than

the proposed method, but the sub-criteria of Supply chain support

and Technology in the traditional average method are higher than

the proposed method. Take Price & Terms criterion for example, we

can find the criterion affected by Supply chain support criterion is

0.571 and Supply chain support criterion affected by Price & Terms
criterion is 1.126 (see Table 3). Obviously, Supply chain support

criterion is affected by Price & Terms criterion more than Price &

Terms criterion is affected by Supply chain support criterion. It re-

presents the influence degree of Price & Terms criterion is more than

that of Supply chain support criterion. The result implies that Price

& Terms criterion is the central criterion for evaluating the appro-

priate vendor. In addition, the results show that the evaluators are

more concerned about the price performance when selecting the

appropriate vendor, which is consistent with the results found in

a real purchase project. From Fig. 6, it can also be seen that the

sub-criteria of Price & Terms criterion are underestimated, whereas

the sub-criteria of Supply chain support criterion are overesti-

mated by applying the traditional average method.

On the other hand, from the causal diagrams (see Fig. 5), we

know the Price & Terms (C2) is the most important and the most

influencing criterion because it has the highest intensity of

relationship to other criteria. Thus, it can be regarded as the critical
criterion for evaluating and improving the appropriate vendor.

To reduce the gaps between the appropriate vendor and aspired

levels (Fig. 4), we can make some suggestions to improve the

465 using the results. Additionally, it can be provided to derive the

influential cluster-weighted supermatrix to obtain the weights of

criteria in ANP method. The ranking results of weights of sub-crite-

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that of Supply chain support criterion. The result implies that Price

& Terms criterion is the central criterion for evaluating the appro-

priate vendor. In addition, the results show that the evaluators are

more concerned about the price performance when selecting the

appropriate vendor, which is consistent with the results found in

a real purchase project. From Fig. 6, it can also be seen that the

sub-criteria of Price & Terms criterion are underestimated, whereas

the sub-criteria of Supply chain support criterion are overesti-

mated by applying the traditional average method.

On the other hand, from the causal diagrams (see Fig. 5), we

know the Price & Terms (C2) is the most important and the most

influencing criterion because it has the highest intensity of

relationship to other criteria. Thus, it can be regarded as the critical
criterion for evaluating and improving the appropriate vendor.

To reduce the gaps between the appropriate vendor and aspired

levels (Fig. 4), we can make some suggestions to improve the
483 performances of the appropriate vendor for each criterion priori-
484 ties from the results of NMR. From the abovementioned analysis,
485 we know the Price & Terms and Quality are the two most impor-
486 tant cause criteria. If we wanted to obtain high performances in
487 terms of the effect criteria (i.e., Supply chain support and Tech-
488 nology), the appropriate vendor would get an improved priority for
489 the two cause criteria beforehand, so that it can successfully to
490 be the best vendor with the approaching-ideal point.

5. Conclusions

Most importance-assessing methods used to demonstrate the
importance of criteria are often based on the assumptions of
additivity and independence. However, in fact, people have found
that using such an additive model is not always suitable in real
world because of the interdependence/interrelation among the
criteria to somewhat different degrees. The ANP method is used
to overcome the problems of dependence and feedback among
criteria, but in the ANP method uses an average method which
normalizes the cluster-weighted supermatrix. The results ignored
the different influence degrees among criteria. To this end,
we propose a novel concept to derive the cluster-weighted
supermatrix to obtain the weights of criteria, in which theto-
total-influence matrix is obtained and regarded as the base of nor-
malization supermatrix for calculating ANP weights using
DEMATEL method. Obviously, it is useful and feasible for solving
the irrational situation. Through the causal diagram (Fig. 5), the
complexity of a problem is easier to capture, so that profound
decision can be made. Finally, we use an empirical applications
in Taiwan is to demonstrate that the proposed method provides
practitioners some important conclusions drawn from this case
applications.

Table 9
Performance matrix of candidate vendor for each criterion.

<table>
<thead>
<tr>
<th>Criteria and sub-criteria</th>
<th>Weights</th>
<th>Candidate vendor (Vj)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>V1</td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Quality performance</td>
<td>0.203 (0.189)</td>
<td>0.620</td>
</tr>
<tr>
<td>– Quality containment &amp; VDCS feedback</td>
<td>0.069 (0.061)</td>
<td>0.720</td>
</tr>
<tr>
<td>Price &amp; Terms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Price</td>
<td>0.235 (0.204)</td>
<td>0.820</td>
</tr>
<tr>
<td>– Terms</td>
<td>0.069 (0.060)</td>
<td>0.620</td>
</tr>
<tr>
<td>– Responsiveness</td>
<td>0.088 (0.077)</td>
<td>0.740</td>
</tr>
<tr>
<td>– Lead time</td>
<td>0.033 (0.028)</td>
<td>0.780</td>
</tr>
<tr>
<td>– VMI/VOI hub set-up cost</td>
<td>0.017 (0.015)</td>
<td>0.780</td>
</tr>
<tr>
<td>Supply chain support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Purchase order reactivity</td>
<td>0.049 (0.057)</td>
<td>0.720</td>
</tr>
<tr>
<td>– Capacity support &amp; flexibility</td>
<td>0.043 (0.061)</td>
<td>0.740</td>
</tr>
<tr>
<td>– Delivery/VMI operation</td>
<td>0.027 (0.037)</td>
<td>0.820</td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Technical support</td>
<td>0.085 (0.106)</td>
<td>0.620</td>
</tr>
<tr>
<td>– Design involvement</td>
<td>0.044 (0.056)</td>
<td>0.680</td>
</tr>
<tr>
<td>– ECN/PCN process</td>
<td>0.038 (0.048)</td>
<td>0.740</td>
</tr>
<tr>
<td>Synthesis scores</td>
<td></td>
<td>0.715</td>
</tr>
</tbody>
</table>

() Represents the results obtained by traditional equal cluster-weighted method (ANP).
* Represents the appropriate vendor.
References


Saaty (1999)