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A Combination of AHP and DEMATEL in Evaluating the Criteria of Employment Service Outreach Program Personnel

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Abstract: Analytic Hierarchy Process (AHP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) method are applied in this study to evaluate the criteria and to construct the contextual relations among the criteria of employment service outreach program personnel. The results generated by AHP can be used for outreach personnel to improve performance from a short period of time. In this case study, social resource link is the most criterion and number of employment and labor information provided, number of local social resources visited and number of employer or employment forums are the three most important second-tier criteria. In contrast to the short time period, the results suggested by DEMATEL method might provide insight for outreach personnel to improve performance from a long time period. This case study shows that job-seeking service is the most critical criterion. Besides, identification of the number of unemployed people and number of follow-up visit might be the two critical second-tier criteria of job-seeking service for outreach personnel to improve performance.

Key words: Analytic hierarchy process, decision-making trial and evaluation laboratory, employment service outreach program, performance evaluation

INTRODUCTION

The latest indicators released by Directorate-General Budget, Accounting and Statistics of Executive Yuan, Taiwan (http://eng.dgbas.gov.tw) show that the current economic and financial crisis has resulted in predicted negative economic growth in 2009 by 2.97% and more importantly, the highest ever unemployment rate of 6.04% in September 2009. The number of 6.04% represents 661 thousand unemployed persons. The unemployment rate has been drastically increasing from 3.80% in early 2008 to 6.04% in September 2009, which has become a tough issue faced by the government. In order to reduce unemployment, the Bureau of Employment and Vocational Training, Council of Labor Affairs of Executive Yuan in Taiwan has been aggressively conducting Employment service outreach program.

Under such program, outreach personnel are recruited, trained and supervised to perform the activities including identifying unemployed persons and then providing job information for them, using the social resource link to increase employment opportunities, conducting employer forum or workshops for job-seekers and so on. If their performance has not been achieved, new recruiters will replace those poor performers. The criteria to evaluate Employment service outreach program personnel were defined by Bureau of Employment and Vocational Training, Council of Labor Affairs of Executive Yuan in Taiwan hierarchically, as shown in Fig. 1. There are three first-tier criteria consisting of job-seeking service, recruitment service and social resource link. The second-tier criteria under the category of job-seeking service include identification of the number of unemployed people, number of introducing job opportunities, number of successful employment, stable employment for three months and number of follow-up visit. For recruitment service, the second-tier criteria are number of employers visited, number of employment
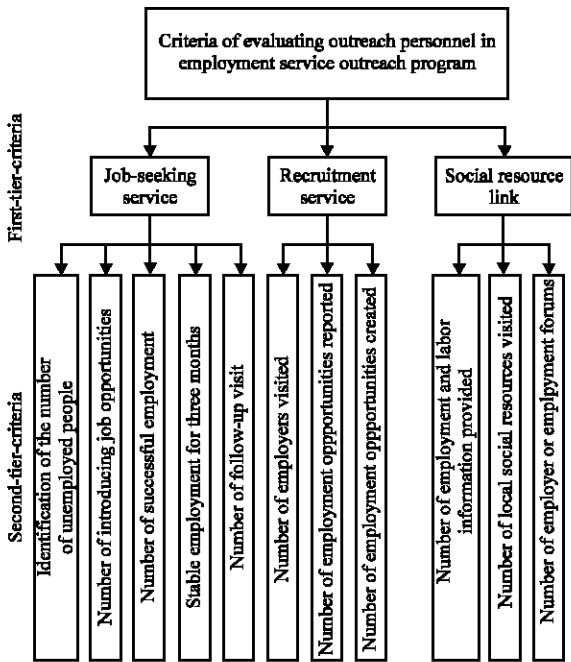

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Fig. 1: The criteria used in performance evaluation for outreach personnel

Table 1: The comparison scale for the importance of criteria

Verbal judgment	Numerical rating
Extreme importance	9
Very, very strong	8
Very strong importance	7
Strong plus	6
Strong importance	5
Moderate plus	4
Moderate importance	3
Weak or slight	2
Equal importance	1

opportunities reported and number of employment opportunities created. Finally, the second-tier criteria of social resource link are composed of number of employment and labor information provided, number of local social resources visited and number of employer or employment forums.

To properly evaluate the performance of outreach personnel, the weight for each criterion should be determined fairly such that the overall evaluation can be more objective. Besides, establishing the causal relationships among the criteria would be helpful for outreach personnel to improve their performance. To achieve the above purposes, this study intends to use a combination of Analytic Hierarchy Process (AHP) and Decision-making Trial and Evaluation Laboratory (DEMATEL) method in Employment service outreach program. Specifically, this study first uses AHP to evaluate the weighting for each criterion and then use DEMATEL method to establish contextual relationships among those criteria.

The analytic hierarchy process, developed by Thomas Saaty, is a very popular method to solve complex multiple criteria decision problems by ranking decision alternatives and selecting the best one when the decision maker has multiple objectives or criteria (Hsu and Chen, 2007; Lee *et al.*, 2009). Akarte *et al.* (2001) summarize that two features of AHP differentiate it from other decision-

making techniques. First, AHP provides a comprehensive structure to combine the intuitive rational and irrational values during the decision-making process. Second, AHP enables the decision maker to judge the consistency in the decision-making process. Saaty (2008) stated that an organized way to make a decision is to decompose the decision into the following four steps: (1) Define the problem and determine the kind of knowledge. (2) Structure the decision hierarchically from the top with the goal of the decision from a broad perspective through the intermediate levels (criteria) to the lowest level (a set of alternatives). (3) Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it. (4) Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below for every element. For each element in the level below, add the weighted values and obtain the overall or global priority. Continue the process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

The specific computations are summarized as follows based on Saaty and Ramanujam (1983), Hsu and Chen (2007), Anderson *et al.* (2007) and Saaty (2008). Suppose C_1, C_2, …, C_n are the set of criteria and a_{ij} represents a quantified judgment on a pair of criteria C_i and C_j. The scale for representing the quantified judgment can be the numerical figure from 1 to 9, as shown in Table 1, for different importance. The pairwise comparison matrix with n criteria is presented below, where a_{12}, for instance, means the quantified judgment between C_1 on the first row and C_2 on the second column:

$$A = \left[a_{ij} \right] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

To compute the priority for each criterion in terms of its contribution to the overall goal, there are three steps in this synthesization procedure. First, sum the values in each column of the pairwise comparison matrix. Second, divide each element in the pairwise comparison matrix by

Table 2: The random index values

n	3	4	5	6	7	8
RI	0.58	0.90	1.12	1.24	1.32	1.41

its column total, which is referred to as the normalized pairwise comparison matrix. Third, calculate the average of the elements in each row of the normalized pairwise comparison matrix. As a result, these averages represent the priorities of the criteria. Later, AHP uses a consistency ratio to evaluate the consistency of the pairwise judgments by the following steps. The first step is to use the pairwise comparison matrix as shown in Eq. 1 to multiply the priorities of the criteria, presented by an $n \times 1$ matrix, computed in the third step of the synthesization procedure. In Step 2, divide the elements of the weighted sum vector obtained in Step 1 by the corresponding priority for each criterion. Third, calculate the average of the values, denoted as λ_{max}, found in Step 2. The fourth step is to compute the consistency index (CI) by:

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

where n is the number of criteria. Finally, in Step 5, compute the consistency ratio by CR = CI/RI, where RI is the random index of a randomly generated pairwise comparison matrix. Table 2 provides RI values with different n. When CR is less than 0.10, the matrix is considered to be consistent.

When AHP is applied in group decision-making processes, two different approaches are used, namely the aggregation of individual judgments and the aggregation of individual priorities (Aczel and Saaty, 1983; Escobar *et al.*, 2004). In this study, the aggregation of individual judgments is applied by the weighted geometric mean method.

DEMATEL method, originally developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976, is to study and resolve the complicated and intertwined problem group through understanding of the specific problematique, the cluster of intertwined problems and contribute to identification of workable solutions by a hierarchical structure (Tzeng *et al.*, 2007; Wu, 2008). This method is one of the structural modeling techniques which can identify the interdependence among the elements of a system through a causal diagram by portraying the basic concept of contextual relationships and the strengths of influence among the elements (Tzeng *et al.*, 2007; Wu and Lee, 2007; Wu, 2008). The procedure of DEMATEL method based on Tzeng *et al.* (2007) and Wu (2008) is as follows:

- **Step 1:** Compute the average matrix. Each respondent was asked to evaluate the direct influence between any two factors by an integer value from 0, 1, 2 and 3, representing no influence, low influence, medium influence and high influence, respectively. The notation of x_{ij} represents the degree to which the respondent believes factor i affects factor j. For i = j, the diagonal elements are set to zero. For each respondent, an $n \times n$ non-negative matrix can be presented as $X^k = [x^k_{ij}]$, where, k is the number of respondents with $1 \le k \le H$ and n is the number of factors. Thus, $X^1, X^2, X^3, ..., X^H$ are the matrices from H respondents. To take into account all opinions from H respondents, the average matrix $A = [a_{ij}]$ is as follows:

$$a_{ij} = \frac{1}{H} \sum_{k=1}^{H} x^k_{ij} \qquad (2)$$

- **Step 2:** Calculate the normalized initial direct-relation matrix D by D = A×S, where,

$$S = \frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}}$$

and each element in matrix D falls between zero and one

- **Step 3:** Calculate the total relation matrix T by $T = D(1-D)^{-1}$, where I is the identity matrix. Define r and c be $n \times 1$ and $1 \times n$ vectors representing the sum of rows and sum of columns of matrix T, respectively. Suppose r_i be the sum of i-th row in matrix T, then r_i summarizes both direct and indirect effects given by factor i to the other factors. If c_j denotes the sum of j-th column in matrix T, then c_j shows both direct and indirect effects by factor j from the other factors. When j = i, the sum (r_i+c_j) shows the total effects given and received by factor i. Thus, (r_i+c_j) indicates the degree of importance that factor i plays in the entire system. In contrast, the difference (r_i-c_j) depicts the net effect that factor i contributes to the system. Moreover, if (r_i-c_j) is positive, factor i is a net cause, while factor i is a net receiver or result if (r_i-c_j) is negative (Liou *et al.*, 2007)

- **Step 4:** Set up a threshold value to obtain the digraph. Because matrix T provides information on how one factor affects another, it is necessary for a decision maker to set up a threshold value to filter out some negligible effects. Only the effects greater than the threshold value are chosen and shown in digraph. In this study, the threshold value is set up

by computing the average of the elements in Matrix T. The digraph can be acquired by mapping the dataset of (r+c, r-c)

Case study: The overall goal is to evaluate the importance of criteria and then to construct the causal relationships among the criteria used for outreach personnel in Employment service outreach program. In order to achieve the above goal, the questionnaire was mailed out to eighteen decision-makers responsible for performance evaluation of outreach personnel from four departments of Bureau of Employment and Vocational Training, Council of Labor Affairs of Executive Yuan in Taiwan from September 2008 to October 2008. Thirteen valid questionnaires have been received, representing a 72% return rate. For duty positions, seven respondents are from Employment Services Division of Bureau of Employment and Vocational Training, including one senior specialist, one deputy director and five section chiefs. In addition, six respondents are station chiefs from Employment Service Stations of Public Employment Services Center. The following computations of using AHP and DEMATEL method are based upon these thirteen experts' opinions.

To first evaluate the importance of these three first-tier criteria by AHP, geometric means method is used to summarize these opinions into the following pairwise comparison matrix:

$$A = \begin{bmatrix} 1 & 0.6440 & 0.3317 \\ 1.5527 & 1 & 0.2350 \\ 3.0150 & 4.2554 & 1 \end{bmatrix}$$

Following the procedures discussed earlier, the weights of job-seeking service, recruitment service and social resource link are 0.1668, 0.1995 and 0.6337, respectively, with CR = 0.060, which is less than 0.10. To further decompose the weights to the second-tier criteria, Table 3 summarizes the information, where the importance resource link (denoted as C) > recruitment service

(denoted as B) > job-seeking service (denoted as A). In addition to the importance of the first-tier criteria, the priorities of all second-tier criteria are $C_3 > C_2 > C_1 > B_2 > B_1 > A_5 > A_1 > B_3 > A_2 > A_3 > A_4$.

To establish the causal relationship, three first-tier criteria are used. The average matrix, based on Eq. 2 and thirteen opinions, are:

$$A = \begin{bmatrix} 0 & 2.692 & 2 \\ 2.692 & 0 & 1.923 \\ 1.846 & 2.077 & 0 \end{bmatrix}$$

The normalized initial direct-relation matrix D becomes:

$$D = \begin{bmatrix} 0 & 0.574 & 0.426 \\ 0.574 & 0 & 0.410 \\ 0.393 & 0.443 & 0 \end{bmatrix}$$

Matrix T is then calculated by:

$$T = D(I-D)^{-1} = \begin{bmatrix} 5.7823 & 6.3210 & 5.4809 \\ 6.0924 & 5.9000 & 5.4244 \\ 5.3644 & 5.5409 & 4.5570 \end{bmatrix}$$

Table 4 depicts the direct and indirect effects of three first-tier criteria. In addition, the threshold value is 5.6070. The digraph of these three criteria is depicted in Fig. 2.

By the same token, the causal relationships among five second-tier criteria of job-seeking service are depicted in Table 5 and Fig. 3. The causal relationships among three second-tier criteria of recruitment service are shown in Table 6 and Fig. 4. Finally, Table 7 and Fig. 5 summarize the causal relationships among three second-tier criteria of social resource link.

From Table 4 and Fig. 2, job-seeking service is a net cause, social resource link is neutral and recruitment service is a net receiver based on (r-c) values. Moreover, job-seeking service and recruitment service are influenced by each other. In addition to three first-tier criteria,

Table 3: The importance weights of all criteria

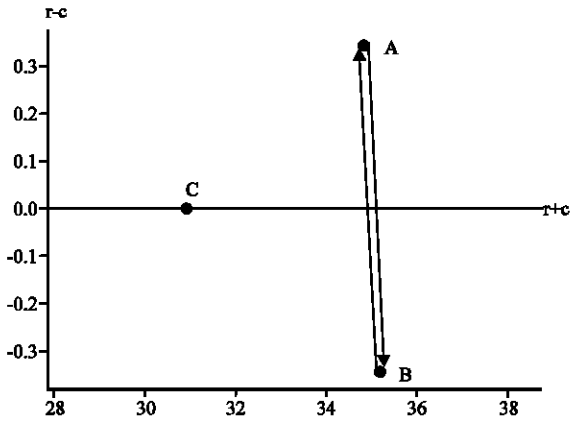| First-tier criteria (Weight)	Second-tier criteria	Weight of second-tier criteria
A. Job-seeking service (0.1668)	A_1: Identification of the number of unemployed people	0.0440
	A_2: Number of introducing job opportunities	0.0309
	A_3: Number of successful employment	0.0264
	A_4: Stable employment for three months	0.0168
	A_5: Number of follow-up visit	0.0487
B. Recruitment service (0.1995)	B_1: Number of employers visited	0.0610
	B_2: Number of employment opportunities reported	0.0991
	B_3: Number of employment opportunities created	0.0394
C. Social resource link (0.6337)	C_1: Number of employment and labor information provided	0.1535
	C_2: Number of local social resources visited	0.2027
	C_3: Number of employer forums or employment forums	0.2774

Fig. 2: The digraph of showing causal relations among these three criteria
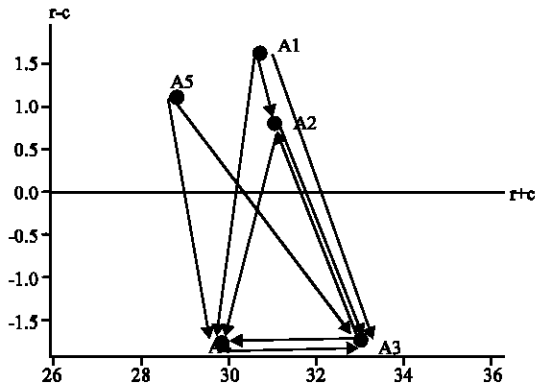

Fig. 3: The digraph of showing causal relations among second-tier criteria of job-seeking service
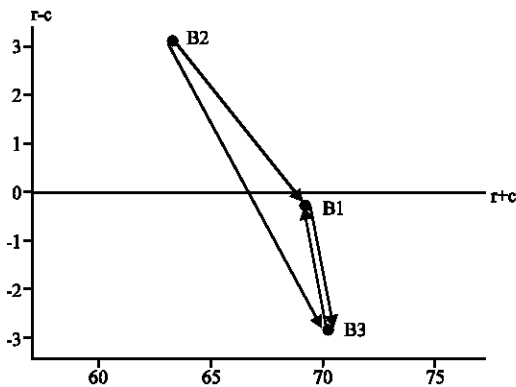

Fig. 4: The digraph of showing causal relations among second-tier criteria of recruitment service

Table 5 shows that A_1, A_2 and A_5 are net causes, while A_3 and A_4 are net receivers in accordance with (r-c) values. From Fig. 3, A_1 and A_5 might be the two most critical
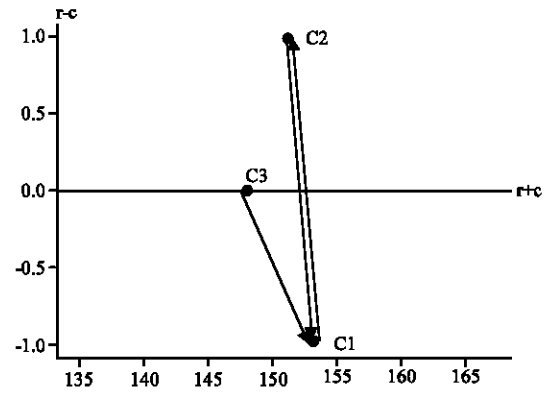

Fig. 5: The digraph of showing causal relations among second-tier criteria of social resource link

Table 4: The sum of influences given and received among these three criteria on dimensions

Dimensions	r+c	r-c
A (job-seeking service)	34.8233	0.3451
B (recruitment service)	35.1787	-0.3451
C (social resource link)	30.9246	0

Table 5: The sum of influences given and received among the second-tier criteria of job-seeking service on dimensions

Second-tier criteria	r+c	r-c
A_1 (identification of the number of unemployed people)	30.6936	1.6150
A_2 (number of introducing job opportunities)	31.0449	0.7873
A_3 (number of successful employment)	32.9835	-1.7381
A_4 (stable employment for three months)	29.7915	-1.7595
A_5 (number of follow-up visit)	28.7951	1.0953

Table 6: The sum of influences given and received among the second-tier criteria of recruitment service on dimensions

Second-tier criteria	r+c	r-c
B_1 (number of employers visited)	69.2789	-0.2809
B_2 (number of employment opportunities reported)	63.3150	3.1078
B_3 (number of employment opportunities created)	70.2569	-2.8269

Table 7: The sum of influences given and received among the second-tier criteria of social resource link on dimensions

Second-tier criteria	r +c	r-c
C_1 (No. of employment and labor information provided)	153.1536	-0.9868
C_2 (No. of local social resources visited)	151.18	0.9868
C_3 (No. of employer forums or employment forums)	148	0

second-tier criteria of job-seeking service since they are the root causes. Table 6 depicts that B_2 is the only net cause, whereas B_1 and B_3 are both net receivers by observing (r-c) values. Besides, from Fig. 4, it is clear that B_2 might be the most critical second-tier criterion of recruitment service since it is the only root cause. Moreover, B_1 and B_3 are affected by each other as well as affected by B_2. From Table 7, C is a net cause, C is neutral and C_1 is a net receiver by (r-c) value column. Further, Fig. 5 illustrates that C_2 is affected by C_1 only, but C_1 is affected by both C_2 and C_3. Specifically, C_1 and C_2 are affected by each other, while there is no criterion to affect

C_3. Therefore, C_3 might be more independent than the other two second-tier criteria under the category of social resource link.

The integration of AHP and DEMATEL method brings the following advantages. First, by observing the weights of first-tier and second-tier criteria from AHP, the outreach program personnel can clearly understand the importance of criteria and how they can improve their performance in a short time period. In contrast to the short period of time, the information from DEMATEL method provides another scenario. There might exist some cause-effect relations among criteria since DEMATEL method includes both direct and indirect effects. The improvement focusing on those effect-oriented criteria might not result in better performance in a long time period. On the contrary, by observing the contextual relations among criteria, the outreach program personnel can figure out how improvement actions should be taken in order to improve the performance effectively. Therefore, the integration of AHP and DEMATEL helps the outreach program personnel plan their improvement in different time periods.

In summary, AHP shows that the outreach program personnel might focus on social resource link more than the other two criteria to improve their performance in a timely basis. Besides, C_1, C_2 and C_3 are the most important second-tier criteria for performance evaluation. Therefore, outreach personnel might pay much attention to these three criteria. However, from the long-term perspective and DEMATEL method, social resource link is relatively neutral to the other two first-tier criteria. That is, improving social resource link in a long time period might not effectively improve performance. On the contrary, job seeking service might be more critical since it is a cause and will directly influence recruitment service. For outreach personnel, improving job-seeking service might be a better choice for the long period of time. Moreover, A_1, A_2 and A_5 are more important second-tier criteria than A_3 and A_4. By further observing Figure 3, A_1 might be the most critical criterion since it influences A_2, A_3 and A_4 directly and is more important than A_5, which only affects A_3 and A_4. Therefore, the improvement should be started with job-seeking service, particularly on identification of the number of unemployed people (A_1) and number of follow-up visit (A_5).

CONCLUSIONS

This study applies AHP and DEMATEL method to evaluate the criteria of Employment service outreach

program personnel. The results provided by AHP can be used for outreach personnel to improve performance from a short time period. Under such circumstance, social resource link is the most important criterion than the other two criteria. Besides, number of employment and labor information provided, number of local social resources visited and number of employer or employment forums are the three most important second-tier criteria. On the other hand, the results suggested by DEMATEL method can be used for outreach personnel to enhance performance from a long period of time. That is, job-seeking service which is a net cause and will directly influence recruitment service is the most critical criterion. By further decomposing the second-tier criteria of job-seeking service, identification of the number of unemployed people and number of follow-up visit might be the two critical second-tier criteria for outreach personnel to improve performance.

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