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RESEARCH NOTE

Determination of a hospital management policy using conjoint analysis in the analytic network process

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Abstract When making management performance decisions, administrators frequently utilize balanced scorecard (BSC) to measure performance because the BSC does not excessively focus on financial measures and seeks a balance among customer perspectives, learning and growth, internal business processes and financial measures. A growing number of studies have applied the analytic hierarchical process (AHP) method to choose BSC metrics for management performance. These AHP methods assume that criteria are independent. Saaty (Decision making with dependence and feedback: the analytic network process. RWS Publications, Pittsburgh, 1996) presented the analytic network process (ANP) method to solve the limitations that criteria are independent. Conventional ANP methods involve complex calculations when the number of criteria increases. Hence, this study attempts to integrate conjoint analysis (CA) and the ANP method to simplify the ANP calculation procedure. Additionally, the decision of management policy is utilized with BSC to determine whether the situation at a hospital demonstrates the feasibility of integrating CA with ANP. Study results reveal that the proposed methodology increases the efficiency of decision making among policymakers and reduces associated risks

Keywords Conjoint analysis · Analytic network process · Analytic hierarchical process · Balanced scorecard · Performance management

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1 Introduction

Successful organizations depend on various indicators of organizational health. These indicators are prospective and enable organizations to plan for the future and respond to problems. When making decisions, administrators have traditionally regarded financial indicators as criteria for measuring performance. However, financial measures are lagging indicators (retrospective); that they report past performance and have limited use when predicting future performance. Therefore, companies in a variety of industries are becoming increasingly dissatisfied with the lack of responsiveness and information provided by traditional performance measures that rely mainly on financial indicators. Companies are seeking management models that recognize the importance of non-financial performance as a driver of financial performance (Voelker et al. 2001). The Balanced Scorecard (BSC) approach avoids excessive emphasis on financial measures and tries to achieve a balance among customer perspectives, learning and growth, internal business processes and financial measures. The BSC has, thus, been implemented at the corporate, strategic business unit, departmental, shared-service and individual levels by hundreds of organizations worldwide, including the business and healthcare sectors and by both private and public enterprises (Voelker et al. 2001). By emphasizing the importance of customer perspective to performance, this BSC significantly influences the progress of organizations in pursuing quality.

An increasing number of studies have adopted the Analytic hierarchical Process (AHP) method. For instance, Hsu and Chen (2005) presented the Fuzzy AHP method to develop and implying a selection model for a retail chain store franchisee involved in bedding. Additionally, an increasing number of studies have applied the AHP method to select metrics of BSC and develop BSC. Clinton et al. (2002) presented that the difficulty lies with the process of choosing metrics of the BSC and using the BSC appropriately. Therefore, Clinton et al. (2002) used the AHP method to systematically select appropriate metrics. However, the AHP hierarchical models that assume independent of elements face certain limitations when the complexity of decision problems increases and interactions among criteria and sub-criteria are not implicitly covered. Given these limitations, Saaty (1996) presented the Analytic Network Process (ANP) method and ANP method that have subsequently been applied to a diverse array of disciplines, including economics, sociology, agriculture and engineering. ANP methods have also been proposed to consider how elements interact with and depend on each other. Similar to AHP, ANP is founded on ratio scales measurement and pairwise comparisons of elements to derive priorities of selected alternatives. Additionally, evaluations include how criteria and sub-criteria are related, allowing dependencies both within a cluster (inner dependence) and between clusters (outer dependence) (Saaty 1996).

Conventional ANP methods utilize not only a comparative matrix to produce the weights, but also a supermatrix to calculate the results. Whereas conventional evaluation models incorporate the ANP method, too few criteria in the evaluation model lead to incomplete results. Conversely, too many criteria not only complicate the model and make evaluation difficult, but also make it extremely difficult to design an ANP-based questionnaire. Restated, the number of questions in a questionnaire is increased, not only causing potential confusion for respondents, but also complicating the follow-up calculation procedure. A situation in which criterion of ANP comparative matrix belongs to a pair requires that two criteria must be compared one time; three criteria must be compared three times; four criteria must be compared six times; and five criteria must be compared ten times. Therefore, a complex calculation procedure increases the number of criteria.

Because AHP and ANP use the same calculation weighting method, Scholl et al. (2005) conducted a study selecting the AHP and the Conjoint Analysis (CA) methods suitable for easy application. Analysis results indicate that the AHP and CA methods use completely different approaches, but obtain similar results. Next, Yoo and Ohta (1995) indicated that one advantage of the full-profile approach is its ability to determine overall preference judgments directly using behaviorally oriented constructs such as intention to purchase, likelihood of trialing a new brand, probability of switching to a new brand and so on. Additionally, Baruch (1997) indicated that CA is introduced to the political world and presented as a superior substitute to conservative popularity contest surveys. Therefore, this study assumes that utilizing CA to derive the weight is closer to the actual condition than the pairwise comparison method, and that utilizing CA to derive the weight can simplify the calculation procedure of the ANP method. Therefore, this study attempts to integrate CA and the ANP method (CA-ANP method) to simplify the ANP method.

Because of budgetary constraints of the Taiwan national health insurance (TNHI), hospitals in Taiwan face reduced incomes and some even face bankruptcy, and so this study uses the management policy at a hospital using BSC as an example to determine actual situations demonstrates the feasibility of applying the approach of CA integrated with ANP. Doing so enables hospital decision makers to evaluate an appropriate number of criteria and select an appropriate decision. First, relevant weight values of each key element are derived using CA. Effective assessment data is then obtained using the supermatrix operation of ANP. Finally, policymakers reach the most appropriate decision by using the final assessment data for evaluation.

2 A hospital case demonstrating the CA-ANP method

The Taiwan National Health Insurance (TNHI) system was introduced in March of 1995. All residents have health insurance coverage rate is up to 96%. To suppress growth in hospitalization costs and to apply resources of TNHI more effective, the TNHI has introduced a global budgeting system. The global budgeting system divides three parts into dentists, Chinese medicine and Western medicine global budgeting system. Western medicine divides two parts into hospitals and clinics. However, a lot of hospitals have been affected by the global budget for Western medicine. Hospitals have been forced to reduce a large of incomes and face going bankrupt. Hospitals strive to go operating. Consequently, hospitals are adopting management policies such as establishing a polyclinic near the hospital, limiting the number of outpatients, etc. Thus, hospitals can earn additional income for their hospital global budgets and for their clinic global budgets. Therefore, to help the hospital making appropriate decisions, this study assesses the feasibility of applying the CA-ANP method using actual example for performance measures for a hospital with BSC.

This case study assesses the feasibility of applying the CA-ANP method in which only five management policies and five performance criteria in the model are utilized to verify the accuracy of the calculation procedure. An illustrative example of the management policy of the hospital with BSC demonstrates the feasibility of applying the integrated method. The detailed calculation procedure is described as follows:

Step 1. Derive the structure of the decision model.

Review the relevant literature to select the criteria and decision model. Health services and management-related literature contains numerous studies reporting on the use of Balanced Scorecard (BSC). Pink et al. (2001) created a BSC for a hospital system that included 89 hospital organizations with 145 sites, and focused on developing measures in the financial performance and condition quadrant. Moreover, Huang et al. (2004) presented the implementation of a BSC in an emergency department of a district hospital in southwestern

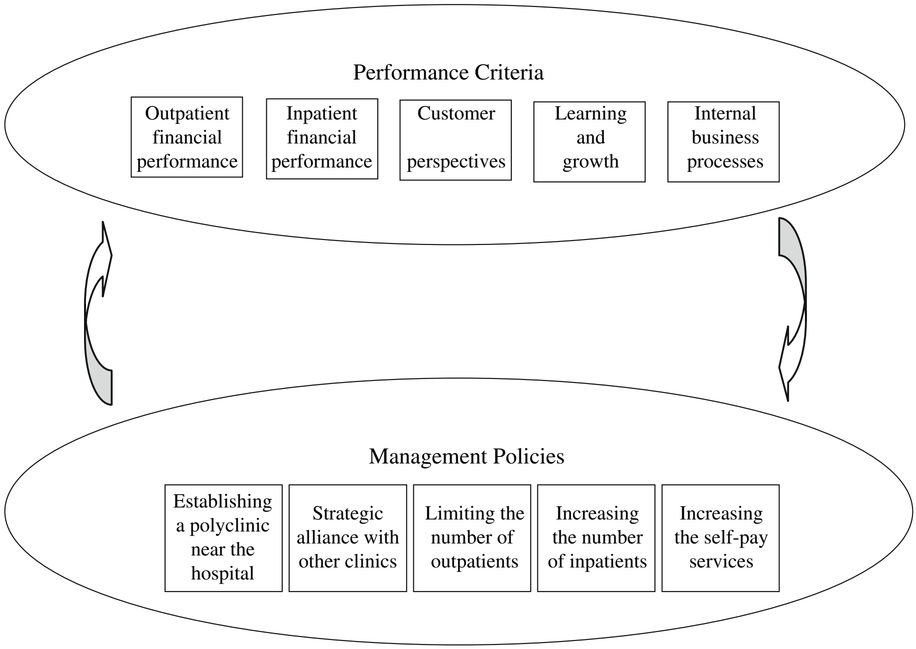

Fig. 1 Management policy modeled with outer dependence

Taiwan, and described the effectiveness of the performance indicators developed for the BSC. Figure 1 shows the decision model used in this study. According to the above-mentioned studies involved in applying BSC in hospitals, we believe that the four perspectives (i.e., financial performance, customer perspectives, internal business processes and learning and growth) of BSC presented by Kaplan and Norton (1992) are appropriate criteria for use in the hospital performance measurement model. However, financial performance can be divided into inpatient financial performance and outpatient financial performance in this study based on hospital characteristics.

Furthermore, the hospital faces the global budgeting system, state the chosen reason of management policies respectively as follows:

1. Establish a polyclinic near hospital: The Western medicine global budget is divided into hospitals and clinics. Establishing polyclinics near the hospital can generate additional income.
2. Strategic alliance with other clinics: To avoid wasting medical resources, the TNHI recommend that people with serious diseases go to the hospital, whereas those with non-serious condition should attend clinics. Consequently, the hospital can create strategic alliances with clinics to create a mutually beneficial relationship. Patients that clinics cannot treat are transferred to the hospital, and the hospital can transfer appropriate patients to the clinic.
3. Limiting the number of outpatients: Due to the global budgeting system, cause the fixed income of hospital, consequently, hospitals are limiting the number of outpatients to reduce health care costs.

4. Increasing the number of inpatients: As the global budgeting system increased the inpatient global budget, hospitals have increased the number of inpatients to increase their income.
5. Increasing self-pay services: Self-pay services, such as cosmetic treatments, weight-loss programs, and health examinations, have been introduced to increase income.

Step 2. Utilize SPSS software to generate an orthogonal table.

SPSS software is used to generate orthogonal tables for criteria and alternatives. To simplify the explanation, particularly since the SPSS software generates numerous orthogonal tables, this study randomly chooses a single orthogonal table.

Step 3. Determine the scores for constituents.

Policymaker rank or score for constituents is based on the orthogonal table of n attributes (Table 1).
Constituent 8 (Table 2) indicates that "establishing a polyclinic near the hospital," "strategic alliance with other clinic," and "limiting the number of outpatients" are equally important and feasible alternatives under outpatient financial performance, thereby explaining why policymakers assign a score of 8. Constituent 3 reveals that "establishing a polyclinic near the hospital," "strategic alliance with other clinic" and "increasing the self-pay services" are equally important and feasible alternatives under outpatient financial performance, thus explaining why policymakers assign a score of 7. The final score is based on the ideal constituent from the policymaker's perspective. Under the performance criterion, hospital policymakers rank the score of constituent (from "not very important" to "very important" on a scale of 1–8) for five items in management policies. Under the management policy, hospital policymakers rank the scores of constituent for five items for performance criteria.

Step 4. Perform regression analysis for estimating the utility function of the CA method.

During this step, regression analysis is performed to generate the utility function of the CA method and the importance of attributes (criteria or alternatives).

$$Y_i = a + b_1 X_{i1} + b_2 X_{i2} + \cdots + b_n X_{in} \quad (1)$$

$$u_j = \frac{b_j}{\sum_{j=1}^{n} b_j} \quad (2)$$

Table 1 Constituent scores based on the orthogonal table

Given criterion or alternative	Constituent 1	Constituent 2	Constituent 3	...	Constituent I
Score of constituent	Y_1	Y_2	Y_3	...	Y_I
Attribute 1	X_{11}	X_{21}	X_{31}	...	X_{I1}
Attribute 2	X_{12}	X_{22}	X_{32}	...	X_{I2}
Attribute 3	X_{13}	X_{23}	X_{33}	...	X_{I3}
Attribute 4	X_{14}	X_{24}	X_{34}	...	X_{I4}
⋮	⋮	⋮	⋮	...	⋮
Attribute n	X_{1n}	X_{2n}	X_{3n}	...	X_{In}

Where Y_i is the score of the i-th constituent ($Y_i = 1$ indicates very unimportant constituent, ..., and $Y_i = I$ indicates very important constituent) and $i = 1, \ldots, I$

Table 2 Score for the constituents for a given performance criterion (outpatient financial performance)

Outpatient financial performance	Constituent1	Constituent2	Constituent 3	Constituent 4	Constituent 5	Constituent 6	Constituent 7	Constituent 8
Score of Constituent	3	1	7	5	6	4	2	8
Establishing a polyclinic near the hospital	0	0	1	1	1	0	0	1
Strategic alliance with other clinic	0	0	1	0	0	1	1	1
Limiting the number of outpatients	1	0	0	0	1	0	1	1
Increasing the number of inpatients	0	0	0	1	1	1	1	0
Increasing the self-pay services	1	0	1	1	0	0	1	0

Table 3 Standardized weights of each submatrix in the supermatrix

	Outpatient financial performance	Inpatient financial performance	Customer perspectives	Learning and growth	Internal business processes	Establishing a polyclinic near the hospital	Strategic alliance with other clinic	Limiting the number of outpatients	Increasing the number of inpatients	Increasing the self-pay services
Outpatient financial performance	0	0	0	0	0	0.52	0.49	0.51	0.05	0.49
Inpatient financial performance	0	0	0	0	0	0.01	0.04	0.15	0.21	0.04
Customer perspectives	0	0	0	0	0	0.29	0.10	0.15	0.21	0.10
Learning and growth	0	0	0	0	0	0.12	0.27	0.15	0.21	0.27
Internal business processes	0	0	0	0	0	0.06	0.10	0.04	0.32	0.10
Establishing a polyclinic near the hospital	0.56	0.56	0.01	0.03	0.09	0	0	0	0	0
Strategic alliance with other clinic	0.26	0.26	0.19	0.09	0.09	0	0	0	0	0
Limiting the number of outpatients	0.14	0.08	0.23	0.58	0.09	0	0	0	0	0
Increasing the number of inpatients	0.02	0.02	0.34	0.15	0.26	0	0	0	0	0
Increasing the self-pay services	0.02	0.08	0.23	0.15	0.47	0	0	0	0	0

Table 4 Limit supermatrix

	Outpatient financial performance	Inpatient financial performance	Customer perspectives	Learning and growth	Internal business processes	Establishing a polyclinic near the hospital	Strategic alliance with other clinic	Limiting the number of outpatients	Increasing the number of inpatients	Increasing the self-pay services
Outpatient financial performance	0.4476	0.4476	0.4476	0.4476	0.4476	0	0	0	0	0
Inpatient financial performance	0.0777	0.0777	0.0777	0.0777	0.0777	0	0	0	0	0
Customer perspectives	0.1846	0.1846	0.1846	0.1846	0.1846	0	0	0	0	0
Learning and growth	0.1881	0.1881	0.1881	0.1881	0.1881	0	0	0	0	0
Internal business processes	0.1019	0.1019	0.1019	0.1019	0.1019	0	0	0	0	0
Establishing a polyclinic near the hospital	0	0	0	0	0	0.3108	0.3108	0.3108	0.3108	0.3108
Strategic alliance with other clinic	0	0	0	0	0	0.1978	0.1978	0.1978	0.1978	0.1978
Limiting the number of outpatients	0	0	0	0	0	0.2296	0.2296	0.2296	0.2296	0.2296
Increasing the number of inpatients	0	0	0	0	0	0.1280	0.1280	0.1280	0.1280	0.1280
Increasing the self-pay services	0	0	0	0	0	0.1338	0.1338	0.1338	0.1338	0.1338

where a is the intercept, b_j denotes the non-normalized weight of the j-th attribute, u_j denotes the importance (normalized weight) of the j-th attribute, $i = 1, \ldots, I$ and $j = 1, \ldots, n$.

Step 5. Integrate the submatrix into a supermatrix.

To understand the interdependence among key elements in the ANP structure, ANP utilizes a supermatrix to determine the relative weight of the key criteria. CA is used to determine the submatrix weight of the supermatrix. If the key criteria do not depend on each other, value of the submatrix is 0. Figure 1 illustrates the main criterion, in which the decision alternatives have an outer dependence relation between the criteria and the alternatives. The weights of submatrix **A** refer to the alternative evaluation control under the main criteria, while the weights of submatrix **B** refer to the main criteria evaluation control under the alternatives. Combining submatrix **A** and **B** allows us to obtain supermatrix **M** of the weight. Table 3 displays the weights of each submatrix in the supermatrix.

Step 6. Adjust the supermatrix.

The values in the columns of the supermatrix achieve a stochastic column (i.e., Each column of the supermatrix would normally be equal to 1). In this study, the values in columns in the supermatrix form a stochastic column because this case assumes that the decision model has an outer dependence relation between performance criteria and management policies.

Step 7. Calculate the limit supermatrix.

In this step, there is an infinite sequence of influence matrices: the matrix itself, its square, its cube, etc., are denoted by $\mathbf{M}^k$, $k = 1, 2, \ldots$. If one takes the limit of the average of a sequence of N of these powers of the supermatrix (i.e., a Cesaro sum), $\lim_{k\to\infty} (\frac{1}{N}) \sum_{k=1}^{N} \mathbf{M}^k$ does the result converge, then limit supermatrix, $\lim_{k\to\infty} \mathbf{M}^k$ exists (Saaty 1996; Wolfslehner et al. 2005). Following iteration, multiplying $(\mathbf{M}^{10})$ can obtain the limit supermatrix **M**, as shown in Table 4.

Step 8. Select the most appropriate alternative.

Finally, analysis results in Table 4 clearly indicate that, for the limit supermatrix with respect to the assessments provided, "Establishing a polyclinic near the hospital" is preferred mainly owing to the outpatient financial performance, although it lags behind the other four in inpatient financial performance, customer perspectives, learning and growth and internal business processes. Our results further demonstrate that the proposed evaluation model successfully integrates the CA and ANP method.

3 Conclusions

The proposed model provides an objective decision model for policymakers. "Outpatient financial performance" is most important performance criterion for the hospital, followed by "learning and growth," "customer perspectives," "internal business processes" and "inpatient financial performance" (Table 4). Inpatient financial performance is clearly less important than other criteria as the TNHI has increased the inpatient global budget; however, outpatient profits will be obviously higher than inpatient profits. Thus, the results of this study demonstrate that "inpatient financial performance" is not the most important criterion for this hospital decision-making.

"Establishing a polyclinic near hospital" is the most appropriate alternative for hospital policymakers. When establishing a polyclinic near hospital, the hospital can expand the number of outpatients from the hospital via the polyclinic, thus increasing overall outpatient numbers and boosting profits. However, hospital policymakers can choose one appropriate alternative and two appropriate alternatives at the same time. For example, "establishing a polyclinic near hospital" is the most appropriate alternative, followed by "limiting the number of outpatients" (Table 4). If a hospital policymaker can choose "establishing a polyclinic near hospital" and "limiting the number of outpatients" at the same time, then outpatients can be easily transferred to the polyclinic near hospital premises. Therefore, the hospital policymaker cannot choose only one appropriate alternative, but can match other policies for joint implementation.

Moreover, this study presents an evaluation model that applies CA to determine the normalized weights of attributes and, then, applies ANP to rank alternatives. The ANP comparative matrix belongs to a pairwise number of comparisons with an increasing number of attributes. When more than five attributes are present, the number of comparisons for CA-ANP is less than that for the conventional ANP method. Therefore, a situation in which the ANP comparative matrix belongs to a pair involving a comparison of more than five criteria is the most appropriate for applying the CA-ANP method. Capable of reducing both the ANP complicated comparative matrix in pairs on the calculation procedure and errors in the follow-up calculation procedure, the proposed CA-ANP method alleviates the burden on questionnaire respondents because the CA-ANP questionnaire orthogonal table is designed to offer the importance of attributes to replace the comparative matrix in pairs. Therefore, study results reveal that the proposed methodology increases the efficiency of decision making among policymakers and reduces associated risks.

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