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Full Length Research Paper

The analytic network process for the banking sector: An approach to evaluate the creditability of emerging industries

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This paper identifies the preferable bank loan quality for reducing non-performing loans (NPL). In combination with the relevant literature and interviews with experts, this study adopts the modified Delphi method and the analytic network process (ANP) to construct an evaluation method and to determine ANP effectiveness. In this study, we apply ANP to construct an evaluation method and introduce four criteria and ten sub-criteria to evaluate six alternative bancassurance alliance models. This paper proves that ANP is an effective tool to provide an accurate solution for the decision maker. The results indicate that executives of banks' decision maker units establish business loan processes to evaluate the emerging industry credit ability model for banking sector.

Key words: Bank loans, credit ability, solar energy industry, modified Delphi method, Analytic Network Process (ANP), Multi-Criteria Decision Making (MCDM).

INTRODUCTION

Liberalization of financial markets caused an increase in the number of domestic banks. The administrators often neglected the importance of credit quality because of business pressure. Led by the government's open financial policy, further stimulated by the country's entry into WTO, Taiwanese banks have aggressively pursued market shares, and the banking environment has been under unprecedented competitive pressure, particularly in the traditional loans sectors. With fierce competition, and the resulting decline in loan quality, the risks of the banking industry increases exponentially, especially at the time of economic downturn. Therefore, banks cannot escape from their risk management responsibilities of promoting bank loan quality to reduce non-performing loans. What bankers ought to do to gain profitability on a continuous basis is to reduce loan risk with appropriate utilization of risk management techniques. Therefore, strengthening banks' risk management systems is seen to be more important than ever before. Additionally, in this rapidly changing world, information technology advances quickly with each passing day; the Internet and commu-nication systems progress and innovate continuously. Improvements in information technology, the Internet, and communication have markedly increased the capacity of businesses to manage operations on a global scale, thus facilitating globalization and internationalization.

However, under the intense pressure of competition due to the globalization and internationalization of enter-prises, firms' survival rates are becoming lower. Many studies have shown the feasibility of establishing systems to automatically alert clients with signals about financial decline in listed companies (Lopez and Saidenberg, 2000; Agrawal et al., 2004; Dell' Ariccia and Marquez, 2004; Wagner and Marsh, 2006; Love et al., 2007; Niinimaki, 2007). Such systems can help firms to auto-mate their operations. These measures have been imple-mented in lending banks after an integrative analysis of

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their feasibility, necessity, and reasonability. However, when banks have to lend to emerging industries, obtaining credit information and data is difficult. To solve this problem, banks should build a credit decision model to monitor and evaluate the credit ability of emerging industries.

Multi-criteria decision making (MCDM) is a methodology that helps decision makers make preference decisions (e.g. assessment, ranking, selection) based on a finite set of available alternatives (courses of action), characterized by multiple, potentially conflicting attributes (Mollaghasemi and Pet-Edwards, 1997; Belton and Stewart, 2002). MCDM provides a formal framework for modeling multi-attribute decision problems, particularly those that demand a systematic analysis, including an examination of the decision complexity, the regularity, the significant consequences, and the need for accountability (Belton and Stewart, 2002). Among the well-known methods, the MCDM has only relatively recently been employed to evaluate organizational performance. MCDM uses a set of attributes to solve a decision prob-lem. Existing evaluation problems or studies have utilized the analytic hierarchic process (AHP) to set up a hierarchical skeleton within which multi-attribute decision problems can be structured (e.g. Byun, 2001; Fogliatto and Albin, 2001; Tam and Tummala, 2001; Khalil, 2002; Ferrari, 2003; Ngai, 2003; Aras et al., 2004; Hwang, 2004; Jose and Ines, 2005; Tolgaa et al.,2005; Changchien and Lin, 2005; Kima et al., 2005; Wu et al., 2007; Wu et al., 2010). The expanding use of AHP has resulted in the development of the analytic network process (ANP). Several studies have adopted ANP to evaluate decision problems (Yurdakul, 2003; Ravi et al., 2005; Chang et al., 2007; Wu et al., 2009). ANP has been successfully applied to a diverse array of problems. For network-like decision models (that is decision problems that can be structured in a network model form), ANP repre-sents an effective tool for providing an accurate solution for administrators or managers (Chang et al., 2007).

This study analyzed a business loan process in which the bank employed the ANP to evaluate the loan. However, this paper proposes an evaluation of an emerging-industry credit model. In this paper, first, we present an evaluation framework through a modified Delphi method. Next, the relative weights of the evaluative criteria are determined using the ANP model, followed by a case to demonstrate the proposed model. The ANP-based decision-making method to construct an evaluation method can provide decision makers or bank administrators with a valuable reference for either evaluating an emerging industry's credit ability to identify the most appropriate firms for risk management, for example, those with irrecoverable loans or credits. Importantly, the proposed model can assist the banking sector to assess an emerging industry's credit ability, making the model highly suitable for academia and commercial purposes.

METHODOLOGY

Analytic network process methodology

The ANP is a comprehensive decision-making technique that captures the outcome of the dependence and feedback within and among clusters of elements (Saaty, 1996). ANP is based on AHP (Saaty, 1980). The ANP is a coupling of two parts; the first consists of a control hierarchy or network of criteria and sub-criteria that control the interactions, while the second is a network of influences among the elements and clusters. Unlike a hierarchy, the ANP uses a network without a need to specify levels. The main reason we chose the ANP as our methodology for selecting the reverse logistics operations is its ability to offer solutions in a complex, multi-criteria decision-making environment. Some of the fundamental ideas in support of ANP are as follows (Saaty, 1999):

a) ANP is built on the widely used AHP.

b) ANP allows for interdependency; therefore, ANP goes beyond AHP.

c) ANP deals with dependence within a set of elements (inner dependence) and among different sets of elements (outer dependence).

d) In the looser network structure of the ANP, any problem may be represented without concern for which criteria come first and which come next, as would be the case in a hierarchy.

e) ANP is a non-linear structure that deals with sources, cycles, and sinks having a hierarchy of linear form with goals in the top level and the alternatives in the bottom level.

f) ANP portrays a real-world representation of the problem under consideration by prioritizing not only the elements but also the groups or clusters of elements, as is often necessary.

g) ANP utilizes the idea of a control hierarchy or a control network in dealing with different criteria, eventually leading to the analysis of benefits, opportunities, costs, and risks.

Whereas AHP represents a framework with a unidirectional hierarchical relationship, ANP allows for more complex interrelationships among decision levels and attributes. The ANP feedback approach replaces hierarchies with networks, in which the relationships among levels are not easily represented as higher or lower, dominated, or being dominated, directly or indirectly (Meade and Sarkis, 1999). For example, the importance of the criteria determines the importance of the alternatives, as it would in a hierarchy, but the importance of the alternatives may, in turn, have an impact on the importance of the criteria (Saaty, 1996). Therefore, a hierarchical structure with a linear, top-to-bottom form is not applicable in a complex system.

A system with feedback can be represented by a network where nodes correspond to the levels or components (Saaty, 1980). The structural difference between a hierarchy and a network is depicted in Figure 1. The elements in a node may influence some or all of the elements of any other node. In a network, there can be source nodes, intermediate nodes, and sink nodes. Relationships in a network are represented by arcs, and the directions of these arcs signify dependence (Saaty, 1996). Interdependency between two nodes, termed outer dependence, is represented by a two-way arrow, and inner dependence between elements in a node is represented by a looped arc (Sarkis, 2003). The process of ANP comprises four major steps (Saaty, 1996; Meade and Sarkis, 1999).

Step 1: Model construction and problem structuring

The problem should be stated clearly and decomposed into a rational system, such as a network. The structure can be obtained by soliciting the opinions of the decision makers through brainstorming or other appropriate methods. An example of the format of a network is shown in Figure 1(b).

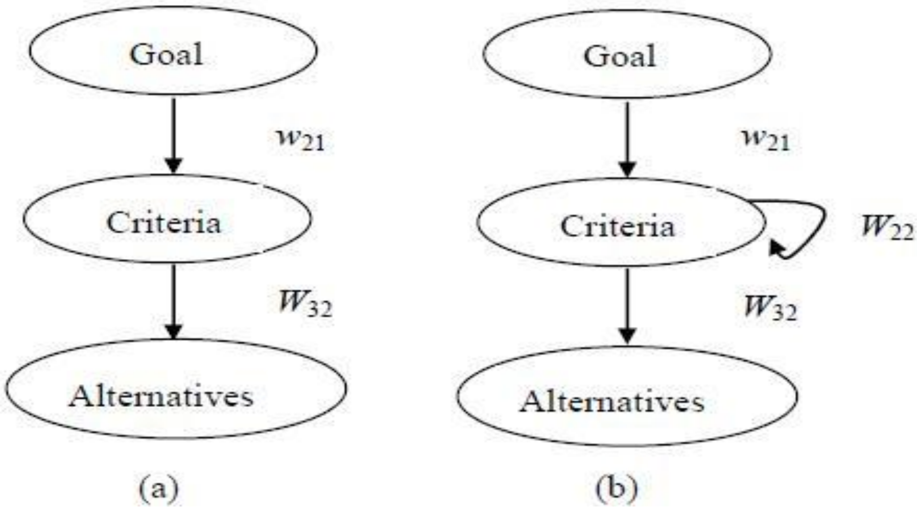

Figure 1. Hierarchy and Network (Momoh and Zhu, 1998): (a) a hierarchy; (b) a network

Step 2: Pair-wise comparison matrices and priority vectors

In ANP, as in AHP, decision elements at each component are compared pair-wise with respect to their importance for their control criterion, and the components themselves are also compared pair-wise with respect to their contribution to the goal. Decision makers are asked to respond to a series of pair-wise comparisons of two elements or two components in terms of how they contribute to their particular upper-level criterion (Meade and Sarkis, 1999). In addition, if there are interdependencies among elements of a component, pair-wise comparisons are also created. An eigenvector can be obtained for each element to show the influence of other elements on it. The relative importance values are determined on a scale of 1 to 9, where a score of 1 represents equal importance of the two elements and a score of 9 indicates the extreme importance of one element (row component in the matrix) compared to the other element (column component in the matrix) (Meade and Sarkis, 1999). A reciprocal value is assigned to the inverse comparison; that is, $a_{ij} = 1/a_{ji}$, where a_{ij} (a_{ji}) denotes the importance of the i^{TH} (j^{TH}) element compared to the j^{TH} (i^{TH}) element. As in AHP, pair-wise comparison in ANP is made in the framework of a matrix. A local priority vector to estimate the relative importance associated with the elements (or components) being compared can be derived by solving the following formula:

$$A \cdot w = \lambda_{max} \cdot w \qquad (1)$$

Where, A is the matrix of pair-wise comparison, w is the eigenvector, and λ_{max} is the largest eigenvalue of Saaty (1980) proposes several algorithms for approximating *w*. In this paper, the following three-step procedure is used to synthesize priorities (Saaty, 1980; Meade and Presley, 2002).

a) Sum the values in each column of the pair-wise comparison matrix.

b) Divide each element in a column by the sum of its respective column. The resultant matrix is referred to as the normalized pair-wise comparison matrix.

c) Sum the elements in each row of the normalized pair-wise comparison matrix, and divide the sum by the *n* elements in the row. These final numbers provide an estimate of the relative priorities for the elements being compared with respect to their upper-level criterion. Priority vectors must be derived for all comparison matrices.

Step 3: Super-matrix formation

The super-matrix concept is similar to the Markov chain process (Saaty, 1996). To obtain global priorities in a system with inter-dependent influences, the local priority vectors are entered in the appropriate columns of a matrix known as a super-matrix. A super-matrix is actually a partitioned matrix, where each matrix segment represents a relationship between two nodes (components or clusters) in a system (Meade and Sarkis, 1999). Let the components of a decision system be C_k, $k = 1, 2, \ldots, n$ and let each component k have m_k elements, denoted by $e_{k1}, e_{k2}, \ldots, e_{km_k}$. The local priority vectors obtained in Step 2 are grouped and located in appropriate positions in a super-matrix based on the flow of influence from a component to another component, or from a component to itself, as in the loop. A standard form of a super-matrix is shown in formula (2) (Saaty, 1996).

$$W = \begin{array}{c c} & \begin{array}{c c c c c c c c c c c} & C_1 & & & & C_k & & & & C_n & \\ & e_{11} \cdots e_{1m_1} & \cdots & & e_{k1} \cdots e_{km_k} & & \cdots & & e_{n1} \cdots e_{nm_n} & & \end{array} \\ \begin{array}{c c} C_1 & \begin{array}{c} e_{11} \\ \vdots \\ e_{1m_1} \end{array} \\ \vdots & \vdots \\ C_k & \begin{array}{c} e_{k1} \\ \vdots \\ e_{km_k} \end{array} \\ \vdots & \vdots \\ C_n & \begin{array}{c} e_{n1} \\ \vdots \\ e_{nm_n} \end{array} \end{array} & \begin{bmatrix} W_{11} & \cdots & W_{1k} & \cdots & W_{1n} \\ \vdots & & \vdots & & \vdots \\ W_{k1} & \cdots & W_{kk} & \cdots & W_{kn} \\ \vdots & & \vdots & & \vdots \\ W_{n1} & \cdots & W_{nk} & \cdots & W_{nn} \end{bmatrix} \end{array} \qquad (2)$$

For example, the super-matrix representation of a hierarchy with three levels as shown in Figure 1(a) is as follows (Saaty, 1996):

$$W_h = \begin{pmatrix} 0 & 0 & 0 \\ W_{21} & 0 & 0 \\ 0 & W_{32} & I \end{pmatrix} \quad (3)$$

where W_{21} is a vector that represents the impact of the goal on the criteria; W_{32} is a matrix that represents the impact of criteria on each of the alternatives; I is the identity matrix; and entries of zero correspond to those elements that have no influence.

For the above example, if the criteria are interrelated among themselves, the hierarchy is replaced by a network, as shown in Figure 1(b). The (2, 2) entry of W_n given by W_{22} would indicate the interdependency, and the super-matrix would be as follows (Saaty, 1996):

$$W_n = \begin{pmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & 0 \\ 0 & W_{32} & I \end{pmatrix} \quad (4)$$

Note that any zero in the super-matrix can be replaced by a matrix if there is an interrelationship of the elements in a component or between two components. Since there usually is interdependence among clusters in a network, the columns of a super-matrix usually sum to more than 1. The super-matrix must first be transformed to make it stochastic; that is, each column of the matrix sums to unity. An approach recommended by Saaty (1996) is to determine the relative importance of the clusters in the super-matrix with the column cluster (block) as the controlling component (Meade and Sarkis, 1999). That is, the row components with nonzero entries for their blocks in that column block are compared according to their impact on the component of that column block (Saaty, 1996). Through pair-wise comparison of the row components with respect to the column component, an eigenvector can be obtained for each column block. For each column block, the first entry of the respective eigenvector is multiplied by all the elements in the first block of that column, the second by all the elements in the second block of that column, and so on.

In this way, the block in each column of the super-matrix is weighted. The result is known as the weighted super-matrix, which is stochastic. Raising a matrix to powers gives the long-term relative influences of the elements on each other. To achieve convergence on the importance weights, the weighted super-matrix is raised to the power of $2k + 1$, where k is an arbitrarily large number. This new matrix, called the limit super-matrix (Saaty, 1996), has the same form as the weighted super-matrix, but all the columns are the same. By normalizing each block of the super-matrix, the final priorities of all the elements in the matrix can be obtained.

Step 4: Selection of best alternatives

If the super-matrix formed in Step 3 covers the whole network, the priority weights of alternatives can be found in the column of alternatives in the normalized super-matrix. On the other hand, if a super-matrix comprises only components that are interrelated, additional calculations must be made to obtain the overall priorities of the alternatives. The alternative with the largest overall priority should be the one selected. In this paper, the first method is applied, and a super-matrix that covers the whole network, as shown by the bracket in Figure 2, is formed.

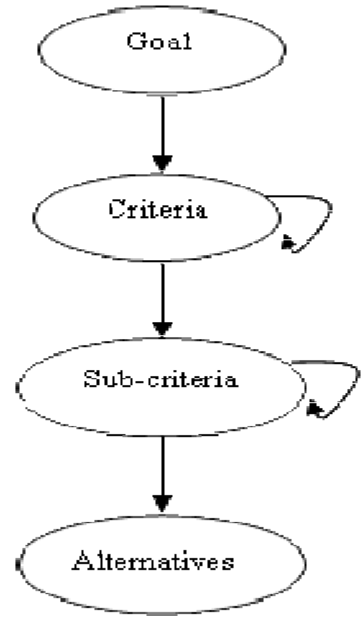

Figure 2. Network form for this paper

A CASE STUDY

In recent years, many countries around the world have increased their research efforts in solar energy. These initiatives have resulted in a range of solar energy-related products to meet diverse consumer needs. A great demand exists for such products—solar energy vehicles, solar energy water heater, solar street light, solar cells, and so on, all of which can work ideally to replace petroleum. The day when solar energy will provide most of humankind's energy requirements is not far off. With strong consumer demand and favorable government policies, a competitive market exists for emerging Industries. The competitive environment lowers firms' survival rates, and irrecoverable loans or credits ability would reduce bank loans risk management.

However, this case study aims to identify the most appropriate firms for bank loan risk management, such as those with irrecoverable loans or credits, in the Taiwanese solar energy industry. First, the proposed framework was constructed through the modified Delphi method. Next, the relative weights of the evaluative criteria were determined using the ANP model. Then, 25 experts rated each criterion on a nine-point scale to determine each of the three candidate firms' credit ability. The experts were proficient in the banking and finance sector. Data were collected through face-to-face interviews by a structured questionnaire. Each interview lasted for approximately an hour. The points were given as genuinely and honestly as possible on the basis of the respondents' experience, without inducing an effect on any variables. The model for evaluating the solar energy industry comprises the following steps to select the appropriate solar energy firm for examination.

Table 1. Evaluate emerging industry credit ability model.

Goal	Criteria	Factor	Alternatives
Evaluate emerging industry credit ability model	Corporation characteristic factor (C_1)	Company Reputation	
		The size of company	
		The likelihood and degree of bank financing	
		Company industry prospect or forecast	
		The company shareholder structure with holds the stock ratio	
		Technology of condition, the origin the company or puts up a factory the experience	Sino-American Silicon (Al_1)
		Management team and relations the management pattern	
	Subject matter of investment (C_2)	The size of investment target	
		The relatedness of investment target	
		The prices of investment target	
	Project remuneration (C_3)	The industry categories	
		The total debt ratio	
		The host localities	
		Anticipated reward rate	
	Market factor (C_4)	Political and economic stability Business Cycle	Wafer Works (Al_2)
		Market shares	
		Circuit and customer	
	Financial risk (C_5)	Financial Reporting	
		Market profitability and Coverage earnings	
		Sources for repayment	
	Project risk (C_6)	Information asymmetry/Cheat risk Financial risk	
		Human resources risk	
		Discontinuance of business risk	Green Energy (Al_3)
	Intellectual capital (C_7)	Enterprise formula	
		Organizational structure capital	
		Human capital	
		Relational structure capital	

Step 1: Establishing an evaluation model and defining the evaluative criteria

On the basis of the Delphi method (Delbecq et al., 1975; Murry and Hammons, 1995; Wu et al., 2007; Wu et al., 2010) and a review of the literature on bank loans risk management with banking and finance sector experts, an evaluation network was constructed as in Table 1 and related reference in Table 2.

Step 2: Establishing the pair-wise comparison matrix and determining eigenvectors

Pair-wise comparisons of level 2 to level 4 were determined for a sample group matching the above characteristics with each respondent making a pair-wise comparison of the decision elements and assigning them relative scores. The relative scores provided by 15 experts were aggregated using the geometric mean method

Table 2. Reference of criteria and sub-criteria.

Criterium	Reference	Sub-criterium	Reference
C_1	Ambrose, B. and Peter, L. (2001)	SC_1	Menon, K. and Williams, J.D. (1994)
		SC_2	Jensen, M.C. and Meckling, W.H. (1976)
		SC_3	Bae, K. H., Kang, J. K. and Lim, C. W. (2002)
		SC_4	Typbjee, T. T. and Albert, V. B. (1984)
		SC_5	Poterba, J. M. and Summers, L. H. (1984)
		SC_6	Hung, S.C. (2002).
		SC_7	Carpenter, M. A., Pollock, T. G. and Leary, M. (2003)
C_2	Trigeorgis, L. (1993)	SC_8	Birkinshaw, J. M. and Morrison, A. J. (1995)
		SC_9	Paul H. (2007)
		SC_{10}	Archibald, R. B., Haulman, C. A. and Moody, C. E. (1983)
C_3	Brucker, P., A. Drexl, R. Mohring, K. Neumann and Pesch, E. (1999).	SC_{11}	Steenackers , A. and Goovaerts, M. J. (1989)
		SC_{12}	Calderon, T. G. and Chen, J. J. (2002)
		SC_{13}	Child, J. (1974)
		SC_{14}	Brinson, G. P., Hood, L. R. and Beebower, G. L. (1991)
C_4	Park, S. (1997)	SC_{15}	Tansey, M., Raju, S. and Stellern, M. (2005)
		SC_{16}	Rose, A. K. and Engel, C. (2002)
		SC_{17}	Kappelman, L. A., Prybutok, V. R. and Myers, B. (1997)
		SC_{18}	Aker, D. A. (1989)
C_5	Miller, D. and Friesen, P. H. (1984)	SC_{19}	Miller, M. H. (1977)
		SC_{20}	Black, E. L. (1998)
		SC_{21}	Myers, S. C. (1977)
C_6	Larson, P. D. and Rogers, D. S. (1998)	SC_{22}	Petersen, K. J., Handfield, R. B. and Ragatz, G. L. (2005)
		SC_{23}	Turner, J. R. and Cochrane, R. A. (1993)
		SC_{24}	Chapman, C. (1997)
		SC_{25}	Jemison, D. B. (1987)
C_7	Byrne B. M., Baron P. and Campbell T. L. (1993)	SC_{26}	Dzinkowski, R. (2000)
		SC_{27}	Churchill, G. A. (1979)
		SC_{28}	Lynn, B. E. (1998)
		SC_{29}	Baruch, L. (1999)

Table 3. Aggregate pair-wise comparison matrix for criteria of level 2.

Goal	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	1	4.545	3.823	3.233	0.372	3.123	4.333
C_2	0.220	1	0.469	0.264	0.237	0.321	0.247
C_3	0.262	2.133	1	0.310	0.288	0.245	0.282
C_4	0.309	3.786	3.223	1	0.308	0.288	0.413
C_5	2.687	4.212	3.468	3.244	1	2.986	3.435
C_6	0.320	3.112	4.122	3.478	0.335	1	2.145
C_7	0.231	4.044	3.542	2.422	0.291	0.466	1

$CR = 0.09 \leq 0.1$

method. For instance, the main criteria are as the sample, such as in Table 3. The priorities for level 2, obtained by the procedure described in Section 2, are as follows:

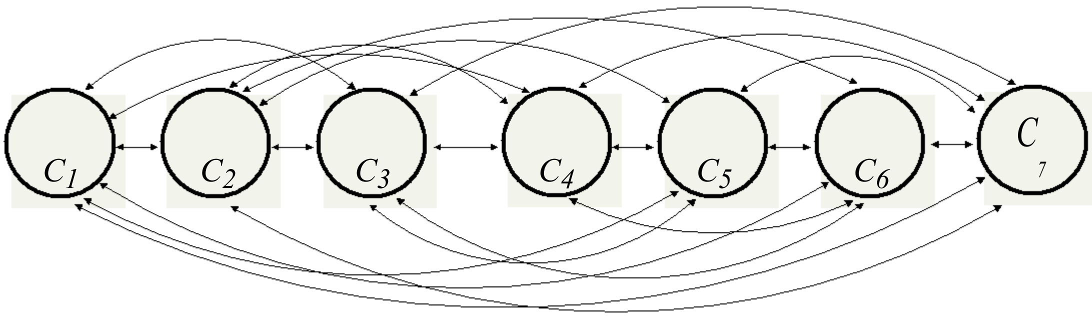

Figure 3. Inner dependence among criteria.

$$W_{21} = \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ C_7 \end{array} \begin{bmatrix} 0.252 \\ 0.037 \\ 0.049 \\ 0.084 \\ 0.314 \\ 0.153 \\ 0.111 \end{bmatrix}$$

The seven evaluative criteria, with the respective weights in parentheses, are as follows: corporation characteristic factor (0.252), subject matter of investment (0.037), project remuneration (0.049), market factor (0.084), financial risk (0.314), project risk (0.153), and intellectual capital (0.111).

The priorities for the alternatives, W_{32}, obtained using the procedure explained in Section 2, are as follows:

$$W_{32} = \begin{bmatrix} 0.288 & 0.470 & 0.315 & 0.305 & 0.526 & 0.276 & 0.478 \\ 0.425 & 0.146 & 0.370 & 0.202 & 0.138 & 0.349 & 0.172 \\ 0.287 & 0.384 & 0.315 & 0.493 & 0.336 & 0.375 & 0.350 \end{bmatrix}$$

Step 3: Establishing matrices of interdependencies and determining eigenvectors

The inner interdependence among the criteria was determined on the basis of the Delphi method (Delbecq et al., 1975; Murry and Hammons, 1995; Wu et al., 2007). The dependencies are shown in Figure 3. The resulting eigenvectors obtained from pair-wise comparisons formed a matrix, W_{22}, are shown thus:

$$W_{22} = \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ C_7 \end{array} \begin{bmatrix} 0.000 & 0.177 & 0.201 & 0.148 & 0.234 & 0.210 & 0.201 \\ 0.224 & 0.000 & 0.148 & 0.116 & 0.116 & 0.117 & 0.116 \\ 0.115 & 0.162 & 0.000 & 0.109 & 0.187 & 0.109 & 0.109 \\ 0.160 & 0.158 & 0.221 & 0.000 & 0.102 & 0.111 & 0.123 \\ 0.211 & 0.186 & 0.153 & 0.216 & 0.000 & 0.253 & 0.251 \\ 0.106 & 0.211 & 0.111 & 0.211 & 0.201 & 0.000 & 0.200 \\ 0.184 & 0.106 & 0.166 & 0.200 & 0.160 & 0.200 & 0.000 \end{bmatrix}$$

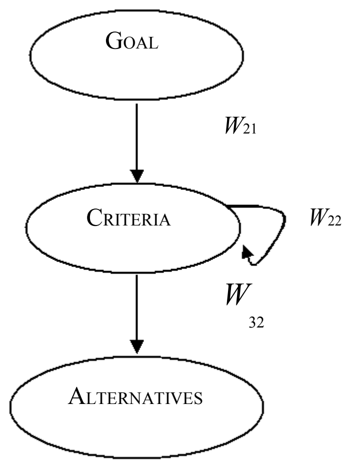

Figure 4. Network form for this case.

Step 4: Testing for consistency

The results of the consistency test and the *C.R.* of the comparison matrix from each of the 11 experts are all < 0.1, indicating 'consistency'. Furthermore, the *C.R.* of the aggregate matrix is also < 0.1, also indicating consistency.

Step 5: Determining the overall level weight to select the ideal solar energy firm.

A supermatrix resolves the effects of interdependence between the system elements. A supermatrix is a partitioned matrix, in which each module comprises the vectors obtained from the pair-wise comparison. In Figure 4, the supermatrix covers all the network elements. Figure 5 shows the generalized form of the supermatrix. Table 4 lists the supermatrix, in addition to the respective vectors and matrices previously obtained. Because the supermatrix includes interactions between clusters (e.g. inner dependence exists among criteria), not all of the columns sum to one. The weighted supermatrix is transformed first into a stochastic matrix, as shown in

$$
\begin{array}{r} \textit{Evaluate creditability (E)} \\ \textit{Criteria (C)} \\ \textit{Alternatives (A)} \end{array}
\begin{array}{c} \\ \end{array}
\begin{pmatrix} & E & C & A \\ & I & 0 & 0 \\ & W_{21} & W_{22} & 0 \\ & 0 & W_{32} & I \end{pmatrix}
$$

Figure 5. Generalized supermatrix.

Table 4. The supermatrix.

	Goal	C_1	C_2	C_3	C_4	C_5	C_6	C_7	AL_1	AL_2	AL_3
Goal	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_1	0.252	0.000	0.177	0.201	0.148	0.234	0.210	0.201	0.000	0.000	0.000
C_2	0.037	0.224	0.000	0.148	0.116	0.116	0.117	0.116	0.000	0.000	0.000
C_3	0.049	0.115	0.162	0.000	0.109	0.187	0.109	0.109	0.000	0.000	0.000
C_4	0.084	0.160	0.158	0.221	0.000	0.102	0.111	0.123	0.000	0.000	0.000
C_5	0.314	0.211	0.186	0.153	0.216	0.000	0.253	0.251	0.000	0.000	0.000
C_6	0.153	0.106	0.211	0.111	0.211	0.201	0.000	0.200	0.000	0.000	0.000
C_7	0.111	0.184	0.106	0.166	0.200	0.160	0.200	0.000	0.000	0.000	0.000
Al_1	0.000	0.288	0.470	0.315	0.305	0.526	0.276	0.478	1.000	0.000	0.000
Al_2	0.000	0.425	0.146	0.370	0.202	0.138	0.349	0.172	0.000	1.000	0.000
Al_3	0.000	0.287	0.384	0.315	0.493	0.336	0.375	0.350	0.000	0.000	1.000

Table 5. The weighted supermatrix.

	Goal	C_1	C_2	C_3	C_4	C_5	C_6	C_7	AL_1	AL_2	AL_3
Goal	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_1	0.126	0.000	0.089	0.101	0.074	0.117	0.105	0.101	0.000	0.000	0.000
C_2	0.019	0.112	0.000	0.074	0.058	0.058	0.059	0.058	0.000	0.000	0.000
C_3	0.025	0.058	0.081	0.000	0.055	0.094	0.055	0.055	0.000	0.000	0.000
C_4	0.042	0.080	0.079	0.111	0.000	0.051	0.056	0.062	0.000	0.000	0.000
C_5	0.157	0.106	0.093	0.077	0.108	0.000	0.127	0.126	0.000	0.000	0.000
C_6	0.077	0.053	0.106	0.056	0.106	0.101	0.000	0.100	0.000	0.000	0.000
C_7	0.056	0.092	0.053	0.083	0.100	0.080	0.100	0.000	0.000	0.000	0.000
Al_1	0.000	0.144	0.235	0.158	0.153	0.263	0.138	0.239	0.000	0.000	0.000
Al_2	0.000	0.213	0.073	0.185	0.101	0.069	0.175	0.086	0.000	0.000	0.000
Al_3	0.000	0.144	0.192	0.158	0.247	0.168	0.188	0.175	0.000	0.000	0.000

Table 6. The limit supermatrix.

	Goal	C_1	C_2	C_3	C_4	C_5	C_6	C_7	AL_1	AL_2	AL_3
Goal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
Al_1	0.369	0.336	0.414	0.343	0.340	0.402	0.328	0.420	0.000	0.000	0.000
Al_2	0.292	0.342	0.220	0.321	0.243	0.279	0.313	0.232	0.000	0.000	0.000
Al_3	0.339	0.321	0.366	0.336	0.417	0.317	0.359	0.348	0.000	0.000	0.000

Table 7. The overall weight to select the ideal solar energy firm.

Criterium	Weight	AI_1 Synthesis value	AI_2 Synthesis value	AI_3 Synthesis value
C_1	0.166	0.336	0.342	0.321
C_2	0.123	0.414	0.220	0.366
C_3	0.117	0.343	0.321	0.336
C_4	0.123	0.340	0.243	0.417
C_5	0.177	0.402	0.279	0.317
C_6	0.148	0.328	0.313	0.359
C_7	0.145	0.420	0.232	0.348
Result	Aggregate score	0.369	0.292	0.339
	Rank	1	3	2

the working of the proposed model. The results show that financial risk (0.177), corporation characteristic factor (0.166), and project risk (0.148) have higher weightings (Table 7). This indicates that the credit information provided to bank administrators should not only focus on traditional financial criteria but also acquaint them with the firm's operating or management characteristics. The synthesis values, also called relative weights, of each of the three solar energy firms are based on the emerging industry targeted for research. Applying ANP to obtain criteria weights and synthesis values for ranking is tantamount to evaluating the criteria of bank loan risk management. With regard to credit ability, the three solar energy firms rank as follows: Sino-American Silicon, Green Energy, and Wafer Works. The proposed model can be of practical use for decision making concerning loans to this emerging industry.

This proven method can evaluate the optimal firm to reduce the risk of irrecoverable loans or credits. The results provide guidance for ranking firms in a multi-criteria environment according to the interrelationship among the criteria. We found that the ANP approach was indeed a promising methodology to evaluate the credit ability of an appropriate candidate in an emerging industry.

REFERENCES

Agrawal V, Kothare M, Rao RKS, Wadhwa P (2004). Bid-ask spreads, informed investors, and the firm's financial condition. Q. Rev. Econ. Financ., 44(1): 58-76.

Anderson DR, Sweeney DJ, Williams TA (1997). An introduction to management science. West Publishing Company, St. Paul, MN.

Aras H, Erdogmus S, Koc E (2004). Multi-criteria selection for a wind observation station location using analytic hierarchy process. Renewab. Energy, 29: 1383-1392.

Belton V, Stewart TJ (2002). Multiple criteria decision analysis: An integrated approach. Boston: Kluwer Academic Publishers.

Byun DH (2001). The AHP approach for selecting an automobile purchase model. Info. Manage., 38(5): 289-297.

Chang CW, Wu CR, Lin CT, Lin HL (2007). Evaluating the digital video recorder systems evaluating digital video recorder systems using analytic hierarchy and analytic network processes. Info. Sci., 177(6): 3383-3396.

Chang SW, Lin MC (2005). Design and implementation of a case-based reasoning system for marketing plans. Expert Syst. Appl., 28: 43-53.

Delbecq AL, Van de Ven AH, Gustafson DH (1975). Group techniques for program planning: A guide to nominal group and Delphi process. New Jersey: Scott, Forestman and Company.

Dell'Ariccia G, Marquez R (2004). Information and bank credit allocation. J. Financ. Econ., 72(1): 185-214.

Ferrari P (2003). A method for choosing from among alternative transportation projects. Eur. J. Oper. Res., 150(1): 194-203.

Forgionne GA, Kohli R (2001). A multi-criteria assessment of decision technology system and journal quality. Info. Manage., 38(7): 421-435.

Hwang HS (2004). Web-based multi-attribute analysis model for engineering project evaluation. Comput. Ind. Eng., 46: 669-678.

Jose LS, Ines H (2005). An AHP-based methodology to rank critical success factors of executive information systems. Comput. Standards Interfaces., 28: 1-12.

Khalil MIA (2002). Selecting the appropriate project delivery method using AHP. Int. J. Project Manage., 20: 469-474.

Kima SS, Yang IO, Yeo MS, Kim KW (2005). Development of a housing performance evaluation model for multi-family residential buildings in Korea. Build. Environ., 40: 1103-1116.

Lopez JA, Saidenberg MR (2000). Evaluating credit risk models. J. Bank. Financ., 24(1-2), 151-165.

Love I, Preve LA, Sarria-Allende V (2007). Trade credit and bank credit: Evidence from recent financial crises. J. Financ. Econ., 83(2): 453-469.

Meade LM, Presley A (2002). R and D project selection using the analytic network process. IEEE Transact. Eng. Manage., 49(1): 59-66.

Meade LM, Sarkis J (1999). Analyzing organizational project alternatives for agile manufacturing processes-An analytical network approach. International J. Prod. Res., 37(2): 241–261.

Mollaghasemi M, Pet-Edwards J (1997). Making multiple-objective decisions. Los Alamitos, CA: IEEE Computer Society Press.

Murry JW, Hammons JO (1995). Delphi: A versatile methodology for conducting qualitative research. Rev. Higher Educ., 18(4), 423-436.

Ngai, E. W . T. (2003). Selection of web sites for online advertising using AHP. Info. Manage., 40(4): 233-242.

Niinimaki, J. P. (2007). Evergreening in banking. J. Financ. Stability., *3*(4): 368-393.

Ravi V, Shankar R, Tiwari MK (2005). Analyzing alternatives in reverse logistics for end-of-life computers: ANP and balanced scorecard approach. Comput. Ind. Eng., 48: 327-356.

Saaty TL (1996). Decision making with dependence and feedback: The analytic network process. RWS Publications, Pittsburgh.

Saaty TL (1980). The analytic hierarchy process. McGraw-Hill Company, New York.

Tam MCY, Tummala VMR (2001). An application of the AHP in vendor selection of a telecommunications system. Omega, 29(2): 171-182.

Tolgaa E, Demircana ML, Kahraman, C . (2005). Operating system selection using fuzzy replacement analysis and analytic hierarchy process. Int. J. Prod. Econ., 97: 89-117.

Wagner W, Marsh IW (2006). Credit risk transfer and financial sector stability. J. Financ. Stability, 2(2): 173-193.

Wu CR, Chang CW, Lin HL (2007). An organizational performance measurement model based on AHP sensitivity analysis. Int. J. Bus. Perform. Manage., 9(1): 77-91.

Wu CR, Chin-Tsai L, Tsai PH (2009). Analysing alternative in financial services for wealth management banks: The analytic network process and the balanced scorecard approach. IMA J. Manage. Math., 20(3): 303-321.

Wu CR, Lin CT, Tsai PH (2010). Evaluating business performance of wealth management banks. Eur. J. Oper. Res., 207(2): 971-979.

Yurdakul M (2003). Measuring long-term performance of a manufacturing firm using the analytic network process (ANP) approach. Int. J. Prod. Res., 41(11): 2501-2529.