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An Integrated Group Decision Making Support Model for Corporate Financing Decisions

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Abstract The essential goal of corporate finance is to maximize corporate value while reducing a firm's financial risks. Corporate financing decision is a kind of multi-criteria based group decision making that embodies major approaches to handle qualitative criteria and quantitative limitations. However, in literature related to financing decision making, very little research uses decision making trial and evaluation laboratory (DEMATEL) and analytic network process (ANP) methods to consider the impact and dependency of its factors, or uses Goal programming (GP) to find the satisfactory financing decision under the related financial constraints. This study proposes an integrated group decision making support (GDMS) model to assist corporate financing group decision makers (DMs) in obtaining a satisfactory group solution. ANP, DEMATEL and GP are combined in this GDMS model. By using this model, the group DMs can systemically structure a multi-criteria network framework and derive priority weights of those criteria, and then deal with the quantitative financial

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constraints for a satisfactory group solution. An illustrative case is demonstrated for the effectiveness and practicability of this GDMS model.

Keywords Group decision making support (GDMS) · Decision making trial and evaluation laboratory (DEMATEL) · Analytic network process(ANP) · Goal programming (GP)

1 Introduction

Financing decision making is a fundamental problem in corporate finance. The essential goal of corporate finance is to maximize corporate value while reducing a firm's financial risks. A wealth-constrained company owner, endowed with a profitable investment opportunity, is driven to raise external capital to finance his investment project by selling securities. The mix of securities may vary in terms of claims to the issuer's future rents and in terms of allocation of residual rights of control (Marques and Coutinho dos Santos 2004). The complexity of financing decision making has elicited a great deal of attention and debate among financial researchers and firms' financial managers. A corporate financing decision is, in fact, a kind of multi-criteria-based group decision making. A multi-criteria decision making (MCDM) method is applied to a decision making problem constrained by uncertain environment and requirement (Kujačić and Bojović 2003). Interdependent relationships exist among the criteria and alternatives. Determining how to evaluate the financing criteria and select the financial alternatives maximizing corporate value, reducing a firm's financial risks and maintaining a firm's financial flexibility, is an important topic.

There are significant debates about the underlying factors that affect financing decision making. Decision problems are influenced by many factors, such as: profit, tax rate, debt capacity, control right, capital cost and the financial covenant of an organization. Capital structure differs for different corporations because the corporations have different reputations (Diamond 1991), scales (Graham and Harvey 2001), types, enterprisers (Zwiebel 1996; Bolton and von Thadden 1998; Fluck 1999a), debt capacities (Lemmon and Zender 2004), life-cycles (Fluck 1999b), financial flexibilities (Pinegar and Wilbricht 1989; Graham and Harvey 2001), etc. Traditional corporate finance theories are unable to shed light on how firms in various situations differ according to the financing decisions they make.

Prior researchers have proposed a number of corporate financing theories to guide decision makers (DMs) in their dealings with financing planning and decision making. Most of those researchers pay close attention to several financial elements, such as cash flow, interest rates, credit rating and information asymmetry. Little help is provided to guide a firm's structure to enable it to make the financing decision best suited to it. In practice, each firm may have diverse financial criteria, strategies and covenants. DMs may give different judgments on the selection of financing criteria. The final decision on satisfactory alternatives to issuing equity security or debt security must be selected from among a set of alternatives under a set of selection criteria, and calls for the creation of an integrated Group Decision Making Support (GDMS) model for corporate financing decision making. The aim in making group decisions for multiple

objectives is to obtain the best group solution that is most acceptable to a group of individuals as a whole, regarding the feasible solutions (Korhonen and Wallenius 1990; Lu and Quaddus 2001). A review of financial decision-based literature shows a lack of studies on the topic of the integration of a firm's interdependent objectives and on the consideration of a firm's financial constraints to find satisfactory financing solutions.

The difficulty and complexity of conducting group decision making in the corporate financing decision field is the fact that group decision making involves all of the decisive member properties, the strategies and portfolios of the enterprise and the environmental constraints on a firm. The basis for decision making is the ability of the decision makers (DMs) to undertake preference judgments on many different alternatives (Beynon 2006). There are three main conflicts among group members within group decision making: group members not having equal importance in a decision activity, group members often having different ideas regarding selection criteria, and the preferences of group members for different alternatives to be proposed (Zhang and Lu 2003). There is no rule to combine individual properties into a group performance unless interpersonal comparison of utilities is allowed (Iz and Jelassi 1990).

The purpose of this paper is to reconcile the conflicting financing criteria and financial limitations by providing an integrated Group Decision Making Support (GDMS) model for corporate financing group DMs. This study proposes an integrated GDMS model that combines analytic network process (ANP) and Decision making Trial and Evaluation Laboratory (DEMATEL) to identify the interactions and derive priority weights of financing criteria. Then goal programming (GP), the well-known multiple-objective programming technique, is applied to select a satisfactory group solution based on the quantitative limitations. This paper is organized as follows: Section 2 collects the relevant capital structure literatures and important impact factors on financing decisions. Section 3 proposes the methodologies of the GDMS model for corporate financing decisions. Section 4 presents an illustration of the financing decisions to support the model. Section 5 offers the discussion and Section 6 is the conclusion.

2 Literature Review

2.1 Corporate Financing

There are a number of theories and elements of corporate financing proposed in prior literatures (see Table 1) but little guidance is provided to help DMs to choose satisfactory financing solutions. Modigliani and Miller (1958) provided the fundamental research into the corporate capital structure problem under conditions of complete, perfect and frictionless markets, where a firm's market value and the welfare of its security holders remain unaffected by financing decisions. M&M's irrelevance theory is not useful in explaining or predicting the capital structural behavior of firms in the real world. The firms are portrayed as single economic agents that follow a specific and pre-determined decision making criterion. This implies that ownership and decision making are congruently tied and, consequently, that there is no role for specialization in ownership and management functions.

Table 1 Summary of the relation between capital structure theories and survey results

Theory or concept	Concepts	Survey evidence support by Graham and Harvey (2001)
Irrelevance theory of firm's market value	A firm's market value and the welfare of its security holders remain unaffected by financing decisions under conditions of complete, perfect and frictionless markets (Modigliani and Miller 1958)	
Trade-off theory of choosing optimal debt policy	Trade-off benefits and costs of debt (Scott 1976) The tax benefits are traded off with expected distress costs or personal tax costs (Miller 1977)	Corporate interest deductions moderately are important Foreign tax treatment is moderately important Cash flow volatility is important Maintaining financial flexibility is important (expected distress costs low)
Firms have target debt ratios	A static version of the trade-off theory implies that firms have an optimal, target debt ratio	44 % have strict or somewhat strict target/range 64 % of investment-grade firms have somewhat strict target/range Target D/E is moderately important for equity issuance decision There are industry patterns in reported debt ratios
The effect of transactions costs on debt ratios	Transactions costs are can affect the cost of external funds Firms avoid or delay issuing or retiring security because of issuance/recapitalization cost (Fisher et al. 1989)	Transactions costs affect debt policy Transactions costs are more important for the debt policy of small firms Transactions costs are relatively important for small, no-dividend firms
Pecking-order theory of financing hierarchy	Financial securities can be undervalued due to informational asymmetry between managers and investors. Firms should use securities in reverse order of asymmetry: use internal funds first, debt second, convertible security third, equity last	Firms value financial flexibility Issue debt when internal funds are insufficient More important for small firms
	To avoid need for external funds, firms may prefer to store excess cash (Myers and Majluf 1984)	Issue equity when internal funds are insufficient Relatively important for small firms Equity issuance decision is affected by equity undervaluation

Table 1 continued

Theory or concept	Concepts	Survey evidence support by Graham and Harvey (2001)
Stock price	Recent increase in stock price presents a "window of opportunity" to issue equity (Loughran and Ritter 1995). If stock undervalued due to informational asymmetry, issues after information release and ensuing stock prices will increase (Lucas and McDonald 1990)	Issue equity when stock price has risen Recent price increase is most important for firms that do not pay dividends (significant) and small firms (not significant)
Credit ratings	Firms issue short-term debt if they expect their credit rating to improve (Flannery 1986)	In general, rating is very important to debt decision
Interest rates	Do absolute coupon rates or relative rates between long and short-term debts which are affected when debt is issued?	Issue debt when interest rates are low Short-term debt should be used moderately to time the level of interest rates because of yield curve slope
Underinvestment	Firm may pass up NPV $>$ 0 project because profits flow to existing bondholders. Can attenuate by limiting debt or using short-term debt Most severe for growth firms (Myers 1977)	Growth status affects relative importance of limiting total debt
Asset substitution	Shareholders take on risky projects to expropriate wealth from bondholders (Jensen and Meckling 1976) Using convertible debt (Green 1984) or short-term debt (Myers 1977) attenuates asset substitution, relative to using long-term debt	
Product market and industry influences	Debt policy credibly signals production decisions (Brander and Lewis 1986)	
	Sensitive-product firms use less debt so customers and suppliers do not worry about firm entering distress (Titman 1984)	Relatively important for growth firms
	Debt ratios are industry-specific (Bradley et al. 1984)	Empirical debt ratios differ systematically across industries

Table 1 continued

Theory or concept	Concepts	Survey evidence support by Graham and Harvey (2001)
Corporate control	Capital structure can be used to affect the likelihood of success for a takeover bid/control contest.	
	Managers may issue debt to increase their effective ownership (Harris and Raviv 1988; Stulz 1988)	Equity issued to dilute holdings of particular shareholders
Risk management	Finance foreign operations with foreign debt as a means of hedging FX risk	Foreign debt is frequently viewed as a natural hedge
Maturity-matching	Match maturity between assets and liabilities	Important to choice between short- and long-term debt
Cash management	Match cash outflows to cash inflows	Long-term debt reduces the need to refinance in bad times
		Spread out required principal repayments or link principal repayment to expected ability to repay
Employee stock/bonus plans	Shares of stock are needed to implement employee compensation plans	When funding employee plans, firms avoid issuing shares, which would dilute the holdings of existing shareholders
Earnings per share dilution		Most important factor affecting equity issuance decision
Managerial over-optimism	Managers suffer from over confidence and over optimism. They think that their stock is undervalued, as well as they hesitant to issue equity securities (Heaton 2002)	
Market timing theory	Capital structure is the outcome of the historical cumulative timing of the market by managers (Baker and Wurgler 2002)	

Data revised from Graham and Harvey (2001)

Many studies provide conflicting assessments about how firms choose their capital structures, with reference to such theories as the Static Tradeoff model (Myers 1977), Pecking Order (Myers 1984), Organizational Behavior (Myers 1993), Managerial Over-optimism (Heaton 2002), and Market Timing theory (Baker and Wurgler 2002). The two most influential theories of capital structure are the Tradeoff (Scott 1976) and the Pecking Order (Myers and Majluf 1984) theories. Both theories assume that managers are the only decision makers behind financial policy. However, surveys by Graham and Harvey (2001) showed that 81 % of firms have considered a target debt

ratio or target range when making their debt decisions. Baker and Wurgler (2002) support the theory that capital structure is the cumulative outcome of a series of market-timing-motivated financing decisions. In contrast to the creditor passivity assumed by prior capital structure theories, a number of literatures hypothesize that creditors may exert control over the security issuance decisions of firms, even outside of bankruptcy (Aghion and Bolton 1992; Dewatripont and Tirole 1994). These researchers argue that creditors may intervene in a firm's financing decisions prior to defaulting in payment, when mangers misbehave or are prone to misbehave. Empirical investigations by Roberts and Sufi (2007) showed that creditors use the transfer of control rights accompanying financial covenant violations to influence corporate debt policy over and above any changes in managers' preferences for debt.

Ownership rights and managerial functions are the central components of financing contractual relationships. Many researchers (Jensen and Meckling 1976; Hansmann 1988; Milgrom and Roberts 1992) argue that individual ownership rights require contracting the allocation of both residual rights of control and residual rents. The Organizational Behavior theory suggests that the value of corporate wealth is composed of the value of its equities and employees' surplus. The organizational balance sheet includes assets and liabilities in terms of the market value. The Managerial Over-optimism model argues that managers suffer from over confidence and over optimism. Market Timing theories suggest that capital structure is the outcome of historical cumulative timing of the market by managers. Managerial incentives theory suggests that a suitable capital structure should describe the control mechanism for adverse incentives created by too little debt and adverse incentives created by too much debt. The neutral mutation hypothesis argues that firms fall into various habits of financing which do not have any impact on value. The Static Tradeoff model does not predict inertia (firms adjust very slowly to their target).

Loughran and Ritter (1995) and Baker and Wurgler (2000) found that there were low stock returns after equity issuance. This theory predicts that fluctuations in debt versus equity issuance could be severe. This is somewhat supported by evidence. This theory predicts that the short-term versus long-term maturity of debt issuance should experience severe swings. This is also supported by evidence from Graham and Harvey (2001) survey. The survey showed that managers try to time the market in their capital structure as it changes. Those managers consider financial flexibility as the most important determinant of their debt policy. They carefully evaluate the different costs between debt and equity for achieving the cheaper cost of capital. This is an important determinant factor that influences the kind of security to issue. Capital structure is largely determined by the history of retained earnings, market price of equity securities, capital cost, default risk, control right and external financing choices. Many explanations or theories of capital structure have validity. The relative importance of different theories partly depends on the quality of corporate governance and the extent of misevaluations.

Graham and Harvey (2001) also found that enterprises are concerned about financial flexibility and credit ratings when issuing debt; when issuing equity, they were concerned about earnings per share dilution and recent stock price appreciation. Their survey also indicated that the size of the firm significantly affected the practice of corporate finance; the majority of large firms have a tight or somewhat tight target debt

ratio in contrast to small firms. Large firms appear to use debt financing conservatively, with the leverage of stable, profitable firms being particularly low. Firms with low or high leverage react differently to external economic shocks.

2.2 Multi-criteria Decision Making in Finance

The nature of the financial decision involves a multi-criteria decision making (MCDM) problem with multiple financial objectives and constraints in times of fierce competition. This study combines Decision Making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process (ANP) approach and the Goal Programming (GP) model to form an integrated GDMS model for corporate financing decisions. In literature dealing with financial decision making, the following authors present some reviews on MCDM problems in finance: (Zopounidis and Doumpos 2002; Steuer and Na 2003; Spronk et al. 2005; Dymowa 2011). The financial decision areas covered in these MCDM literature reviews include: corporate financial planning, capital budgeting, financial investment, financial risk assessment and other financial areas. This paper focuses on corporate financial planning. The methods used in the abovementioned MCDM literature reviews include: goal programming (GP), multiple objective programming, Analytic Hierarchy Process (AHP), Elimination Et Choice Translating Reality (ELECTRE), Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE), Multiattribute Utility Theory (MAUT), Utilités Additives (UTA), Utilités Additives Discriminantes (UTADIS), Multi-group Hierarchical Discrimination (MHDIS) and other methods.

Usually, AHP is used to achieve the relative weights of alternatives where evaluation criteria are independent. However, it is not easy to find the weights if there exist interdependent relationships among evaluation criteria for a given problem. Under this circumstance, ANP should be used instead of AHP. In addition, DEMATEL can be used to examine the mutual relationships of interdependency and the strength of interdependence among various criteria. In recent years, DEMATEL associated with AHP/ANP has been applied in various research areas (Tsai and Hsu 2008; Lee et al. 2009a; Tsai and Chou 2009; Tsai et al. 2010; Ho et al. 2011; Tsai et al. 2011; Chou et al. 2012). Furthermore, GP can be used to find the most suitable alternative mix under several resource and other constraints. Current researchers seldom apply the integrated approach of DEMATEL, AHP/ANP and GP in their analysis of financial decision making.

Table 2 shows the comparisons of some recent MCDM researches in finance and this research. These take into account the following assessment criteria: (1) whether the criteria dependency is considered, (2) whether an objective method of criteria dependency determination is used, (3) whether multi-objectives are considered, and (4) whether multiple financial constraints are considered. Note that the research topics of the researches mentioned in Table 2 are not all identical to this research. In summary, this research simultaneously considers criteria dependency and multiple financial objectives and constraints, and uses an objective method to determine whether the criteria are interdependent.

Table 2 Comparisons of some recent MCDM researches in finance and this research

Author	This research	Xiang (2009)	Schinas (2005)	Ho et al. (2011)	Xidonas et al. (2009)	Lee et al. (2009a)	Lee et al. (2009b)
Research topic	An integrated group decision making support (GDMS) model for corporate financing decisions	MCDM problems for enterprise supply chain finance cooperative systems	Application of MCDM techniques in finance: the case of the Greek coastal shipping companies	Portfolio selection based on capital asset pricing model (CAPM)	Common stock portfolio selection	Stock selection based on Fama-French three-factor model	Stock selection based on Gordon model
Methodology	DEMATEL; ANP; GP; GDM	GDM; CNN	AHP; GDM	DEMATEL; ANP	ELECTRE	DEMATEL; ANP; VIKOR	ANP
Criteria dependency	Yes	No	No	Yes	No	Yes	Yes
Method of criteria dependency determination	DEMATEL	–	–	DEMATEL	–	DEMATEL	No
Multi-objectives	Yes	No	No	No	No	No	No
Multiple financial constraints	Yes	No	No	No	No	No	No

MCDM Multi-criteria decision making, *DEMATEL* decision making trial and evaluation laboratory, *AHP* analytic hierarchy process, *ANP* analytical network process, *GP* Goal programming, *GDM* group decision making, *CNN* cooperative neural network, *ELECTRE* elimination et choice translating reality; *VIKOR* VIseKriterijumska Optimizacija I Kompromisno Resenje

3 The Methodological Framework and Group Decision Making Support Model Design

The multiple objectives of corporate financing decision problems require an integrated Group Decision Making Support (GDMS) model for those group decision makers (DMs). This study combines DEMATEL, ANP and GP models to form an integrated GDMS model for corporate financing decisions. Group DMs involved in corporate financing can apply this model to evaluate the complex interactions of financing criteria to select the optimum financial planning tools.

3.1 Integrated Group Decision Making Support Model Framework

Evaluating financial objectives or criteria and considering the financing covenants and constraints on corporate environments are the basic tasks in financing decision making. This integrated GDMS model can assist decision makers in resolving multi-criteria decision financial problems by evaluating the interactive relationships among financial objectives and alternatives of a firm. This model combines the ANP approach, DEMATEL method and GP model. The processes are described as follows: first, the financial managers can brainstorm or use the nominal group technique (NGT) to gather important impact factors and extract the important factors and financial constraints of corporate financing decisions. Second, the DEMATEL method is applied to structure the direct/indirect relations between each two evaluating criteria, and then the ANP approach is adopted to structure the financing decision framework and obtain the network priority weights of alternatives. Finally, the decision makers combine the ANP weights with the GP model to find a satisfactory solution under the constraints of a firm's environment or plans (Fig. 1).

3.2 Analytic Network Process Approach

The Analytic Network Process is an extension of the well-known Analytic Hierarchy Process (Saaty 1980). The AHP approach is a comprehensive framework that is designed to cope with the intuitive, the rational and the irrational when making multi-objective and multi-criteria decisions with and without certainty for any number of alternatives. AHP can also be employed to determine the degree of functional independence of an upper part or a cluster of a hierarchy from all its lower parts, and the criteria or components at each level. AHP is most appropriate for the situations where the costs and benefits of alternatives are not known, resource consumptions are not limited, interdependences of alternatives are nonexistent or an optimal solution is unnecessary. Several researchers have used AHP in the field of group decision making (Moreno-Jiménez et al. 2005, 2008; Beynon 2006).

Saaty (2001) developed the ANP for decision making priorities without making assumptions about a unidirectional hierarchical relationship among decision levels. Rather than a strict linear top-to-bottom hierarchy, the ANP model provides a loose network structure representing a decision problem (Saaty and Vargas 1998). The relative importance or strength of each effect on a given element is measured on a ratio

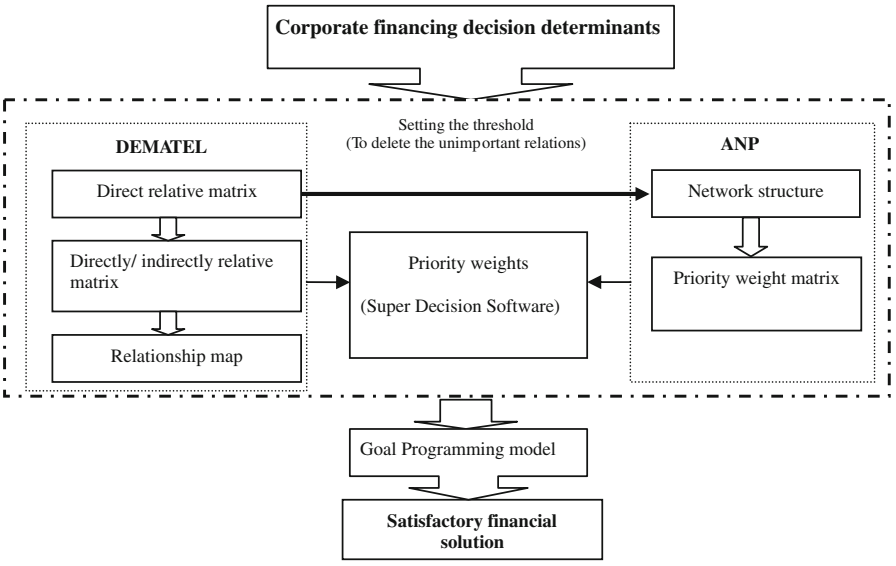

Fig. 1 The framework of the integrated GDMS model for corporate financing decision

scale similar to AHP (Shyur 2003). The process utilizes pair wise comparisons of the project alternatives and comparisons of the multi-criteria. The major difference between ANP and AHP is that ANP can handle interdependences of higher-level elements from lower-level elements, and the independence of the elements within a level, by obtaining the composite weights through the development of a super-matrix. The super-matrix is a partitioned matrix where each sub-matrix is composed of a set of relationships between two components or clusters in a connecting network structure. Saaty (2001) suggested the super-matrix for solving network structures.

The ANP methodology can support complex, networked decision making with various intangible criteria. It improves the visibility of decision making processes and generates the priorities of the decision alternatives (Hallikainen et al. 2006). Saaty recommends using ANP to solve the problem of interdependent relationships among the criteria. The ANP approach consists of two stages: the construction of the network and the calculation of the priorities of the elements. All of the interactions between the elements should be considered when building the structure of the problem (Karsak et al. 2002). These interactions are evaluated using pairwise comparisons. A super-matrix is raised to limiting powers to determine the overall priorities, thus obtaining the cumulative influence of every element on each other.

Figure 2 shows the difference of structures and corresponding super-matrix of a network hierarchy. An arc arrow represents the interdependences between two components, and a loop arrow reveals the inner interdependence (Sarkis 2003). W_{GC} is a vector that represents the impact of the goal on the criteria; W_{CC} is a matrix that represents the impact between each criterion; W_{CA} is a matrix that represents the impact of those criteria on each alternative; W_{AG} is a matrix represents the impact of

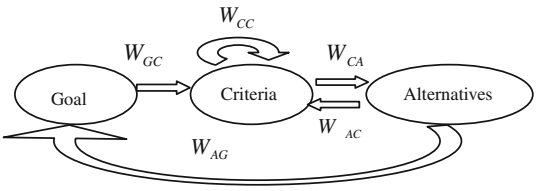

Fig. 2 Nonlinear network

those alternatives on each goal; W_{AC} is a matrix that represents the impact of those alternatives on each criterion; and I is the identity matrix.

$$W = \begin{array}{c} \\ Goal(G) \\ Criteria(C) \\ Alternatives(A) \end{array} \begin{array}{c} \begin{array}{ccc} \mathbf{G} & \mathbf{C} & \mathbf{A} \end{array} \\ \begin{pmatrix} 0 & 0 & W_{AG} \\ W_{GC} & W_{CC} & W_{AC} \\ 0 & W_{CA} & I \end{pmatrix} \end{array}$$

3.3 DEMATEL Method

The DEMATEL (Decision Making Trial and Evaluation Laboratory) method was developed in the Battelle Geneva Institute to analyze complex problems using interactive model techniques and to evaluate quantitative and factor-linked aspects of social problems (Tamura et al. 2003). DEMATEL was used for the fragmented and antagonistic phenomena of world societies and to develop integrated solutions. This method tries to achieve a weighted hierarchical structural model by analyzing the quantitative data on the strength of pair relations on each two factors. It has been successfully applied in many fields. For example, Tamura et al. (2002) used the DEMATEL method to extract various difficult factors in real life, Yamazaki et al. (1997) analyzed obstructive factors of the welfare service using the DEMATEL method, and Hori and Shimizu (1999) employed the DEMATEL method to design and evaluate software for a display-screen structure used in analyzing a supervisory control system.

The DEMATEL method is important and useful for determining the structural model of a problematique in which it is possible to prioritize multiple strategies to improve its structure. A complex problematique is composed of several factors. The steps of DEMATEL are as follows:

1. Extracting the factors and investigating binary relations: We extract all the problematique factors and identify the binary relations and strength for finding the causality.
2. Deriving the direct-relation matrix: If the problematique is composed of n factors, the $n \times n$ matrix X is obtained by comparing the binary relations and strength. X is the direct matrix. The (i, j) element x_{ij} of matrix X denotes the amount of direct influence from factor i to factor j. The amount of x_{ii} is zero.
3. Normalizing the direct-relation matrix X: The matrix X is normalized as $Y = \lambda \cdot X$. By using $\lambda = 1/\max_{1 \le i \le n}(\sum_{j=1}^{n} x_{ij})$, we can derive the normalized matrix Y.
4. Deriving the direct/indirect matrix T: Since $\lim_{\theta \to \infty} Y^{\theta} = [0]$, then we determine: $T = Y + Y^2 + \cdots = Y(I - Y)^{-1}$. Matrix T is the direct/indirect matrix.

The (i, j) element t_{ij} of matrix T denotes the direct and indirect influence from factor i to factor j.

5. Obtaining a causal diagram: Suppose D_i represents the row sum of ith row of matrix T. It shows the sum of influence dispatching from factor i to the other factors both directly and indirectly. Suppose R_i denotes the column sum of ith column of matrix T, then R_i represents the sum of influence that factor i receives from the other factors. The sum of rows and columns $(D_i + R_i)$ denotes the index representing the strength of influence, both dispatching and receiving. This shows the degree to which factor i plays a central role in the problematique. When $(D_i - R_i)$ is positive, it shows that factor i is dispatching the influence to the other factors. If $D_i - R_i$ is negative, it means that the factor i is receiving the influence from the other factors.

3.4 Goal Programming Method

Goal Programming (GP) is a well-known multiple-objective programming technique, which permits the consideration of finite resources and selection limitations that must be rigidly observed in decision making problems. GP stems from the work of Charnes and Cooper (1961), with further development by many researchers (Jones et al. 1998; Romero 2001; Pal et al. 2003). The purpose of GP is to minimize the deviations between the achievement of goals and their aspiration levels. The conflicts of resources and the incompleteness of available information in the real world make it almost impossible for DMs to build a reliable mathematical model for representation of their preferences. In order to overcome this problem, DMs try to determine a set of goals to get acceptable solutions whereby they are able to minimize the deviations between the achievements of goals and their aspiration levels. In the real world, there are many imprecise aspiration levels. They are somewhat larger than, equal to, or substantially lesser than the vague goal g_i. The GP model can handle multi-criteria decision making problems and attain the objectives of an organization while considering restricted resources. The model is described as follows:

$$Minimize \;\; Z = P_K(w_j d_i^+, w_j d_i^-)$$

$$\text{Subject to:} \;\; \Sigma_j a_{ij} x_j + d_i^- - d_i^+ = b_i \quad \text{for} \quad i = 1, 2, \ldots, m, \; j = 1, 2, \ldots, n$$

$$d_i^+ \geq 0, d_i^- \geq 0 \quad \text{for} \quad \forall_i$$

where Z denotes the sum of the deviation from m goals; n is the pool of alternatives; P_K represents a preemptive priority $(P_1 > P_2 > P_3 >>> P_K)$ for goal k; d_i^+ and d_i^- are the positive or negative deviation variables for the selection criterion i; w_j represents the priority weight on the jth limitation; a_{ij} is the parameter j of selection criterion i; b_i denotes the necessary limitation that must be considered in the selection decision, and x_j represents the alternative.

4 Case Study: An Integrated GDMS Model for Corporate Financing Decisions

Without loss of generality, theoretical literature on capital structure emphatically assumes that investors provide external financing by means of two major types of contracts: debt and equity. Therefore, a number of characteristics often found in real world corporate security issuances are considered in this case. The following assumed case is used for demonstrating the processes of this integrated GDMS model for financing decisions.

The assumed KI Company is a public trade company in the U.S. that has several investment projects requiring an additional $2.0 USD million. The enterprise cannot generate this much money and retain cash. The relevant situation of KI includes the following: long term debt ratio is 35 %, the current liability ratio is about 5 % of total assets and the price of common stock is same as the book value without premium or discount. The assets of KI Corporation total $10 million, including: bank loans of $2.5 million, corporate bonds of $1.0 million, preferred stock of $0.5 million, retained earnings of $0.2 million, and common stock of $5.8 million. There are six financial managers of KI. There are four alternatives for KI to finance funds: corporate bonds, bank loans, common stock and preferred stock.

To obtain additional capital, KI collects and evaluates relevant information to make a sound financing decision. KI Company has issued corporate bonds to gather funds; there are mandated constraints on the financial covenants of KI. To comply with these financial covenants, the long term liability ratio for any fiscal quarter must not exceed 40 %. To remain flexible, the board of directors of KI sets the upper level of long term liability ratio to 36 %, and the weighted average capital cost (WACC) to a value lower than 13 % before considering the benefits of a tax shield of debts. The total flotation cost for the financing should not exceed $30,000 and the total interest expenditure of long term liabilities must be lower than $0.5 million. The flotation cost for preparation of financial statements is $13,000 and requires additional expenses like prospectuses which are 0.8 % of the amounts of issuing corporate bonds, 0.85 % of the amounts of the issuing preferred stocks and 1 % of the amounts of issuing common stocks. The bank loans just need financial statements without other expenses. The board of directors proposes two flexible limitations: the weighted average costs of capital which should not be lower than 10 % before considering the benefits of tax shield of debts, and the total interest expenditure of long term liabilities should not be lower than $350,000 for tax planning.

4.1 Constructing Corporate Financing Decision Making Structures

Corporate financing decision is a multi-criteria-based group decision making. Group decisions for multiple objectives or criteria prefer to obtain satisfactory group solutions. The six financial managers of KI have a financial conference to discuss and extract the financial criteria and financial strategies for corporate financing decisions. Each financial manager is asked to propose several financial objectives and financing plans by brainstorming; this results in the extraction of 13 financing criteria: the benefits of debt, costs of capital, default risk, creditor takeover, corporate control, earnings

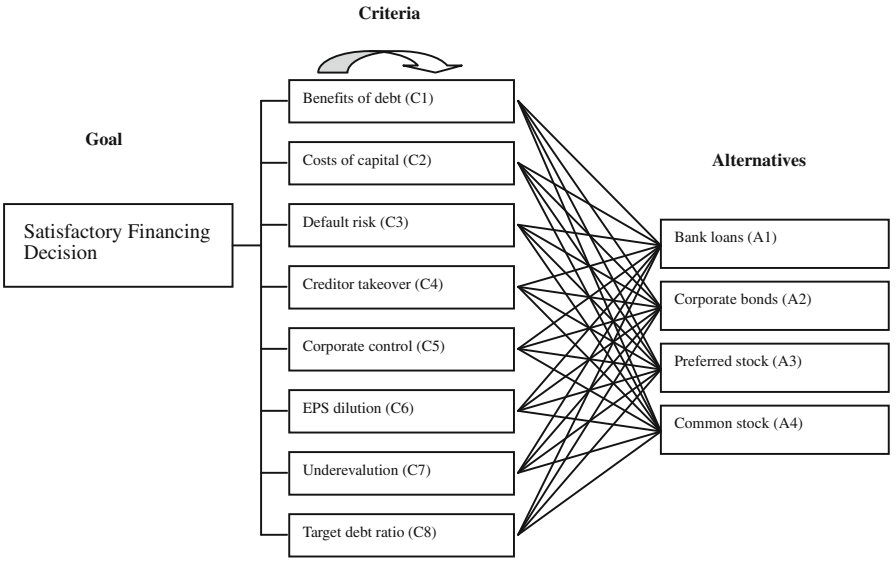

Fig. 3 Financing decision making structure

per share dilution, undervaluation, target debt ratio, financial flexibility, interest rates, stock price, cash flows and debt ratio.

The Nominal Group technique (NGT) is used for identifying the important criteria that impact corporate financing decisions. The results of using NGT identify eight important criteria: benefits of debt, costs of capital, default risk, creditor takeover, corporate control, earnings per share dilution, undervaluation and target debt ratio. The analytical network framework for financing decisions is shown in Fig. 3. The goal of the financing decision is the highest level of the hierarchy, and the eight important determinants are the criteria for decision making. There are four alternatives for financing. The arrow above the eight criteria in Fig. 3 represents the interdependent relationships among those criteria. The DEMATEL method is used to derive the interactions of the criteria

4.2 Evaluating Relationships Between Criteria by DEMATEL

Interactions may exist among the eight crietria. DEMATEL can be used for evaluating the interactive relationships between any two criteria. All the six financial managers are asked to evaluate the importance of the relationships among the eight criteria by pairwise comparisons using a 5-point scale ranking from 4 (extremely important) to 0 (no effect). The direct-relation matrix X is shown in Table 3. A threshold value of 0.58 is chosen in consultation with those financial managers. The value under 0.58 results in a relationship that is too complex for the whole system structure. The impact relations' map of the DEMATEL method is showed in Fig. 4.

The group DMs of KI obtains structural models of impact factors in financing decisions. They then find factors with high $(D + R)$ values that play a central role, factors

Table 3 The total-influence matrix X and the sum of influence given and received on eight criteria

	C1	C2	C3	C4	C5	C6	C7	C8	D+R	D-R
C1	0.406	0.533	0.596[a]	0.651[a]	0.439	0.326	0.605[a]	0.488	8.011	0.077
C2	0.519	0.431	0.658[a]	0.682[a]	0.465	0.343	0.635[a]	0.549	8.251	0.314
C3	0.626[a]	0.628[a]	0.581[a]	0.818[a]	0.617[a]	0.440	0.752[a]	0.586[a]	9.637	0.458
C4	0.515	0.516	0.619[a]	0.565	0.590[a]	0.396	0.628[a]	0.514	9.490	−0.806
C5	0.361	0.360	0.413	0.569	0.327	0.356	0.417	0.399	7.109	−0.703
C6	0.468	0.468	0.564	0.552	0.543	0.276	0.534	0.467	6.669	1.076
C7	0.573	0.574	0.643[a]	0.740[a]	0.482	0.355	0.530	0.567	9.126	−0.200
C8	0.498	0.460	0.515	0.571	0.443	0.304	0.562	0.368	7.660	−0.217

[a] The threshold is 0.58

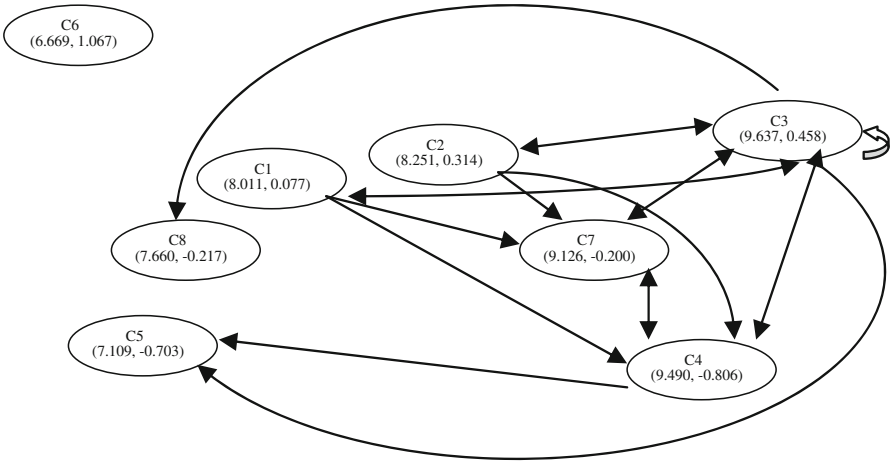

Fig. 4 The impact-relation-map of relations within financing criteria

with high $(D - R)$ value that mainly dispatch influence to other factors and factors with low $(D - R)$ value that mainly receive influence from the other factors. Finally, the group of DMs applies the impact-relation-map to identify the interdependent relationships between each two of those criteria.

4.3 ANP Priority Weights

After determining the relationship structure system of the corporate financing criteria, the ANP approach is applied to derive the priority weights of criteria. The initial importance of relationships among the criteria is obtained, based on the impact-relation-map of Fig. 4. The pairwise comparisons between financing criteria are based on Sasty's 9 points scale, where scores of 1 and 9 are of equal importance showing the extreme importance of one factor over another. Then, the Super Decisions software is employed for calculating the weights. By applying powers of the super matrix, the indirect effects of the feedback relationships are cumulated towards the equilibrium. The results of pair wise comparisons (weights in priority vectors) are stored as matrices

and in a super matrix consisting of the lower level matrices. Table 4 shows a partially weighted super matrix. Table 5 depicts a partially limited matrix.

After the super matrix is 'normalized', the column stochastic arbitrary large number of powers of the matrix is taken; this is the idea and challenge of ANP. Using our ANP structure, the ANP weights of the four alternatives are obtained as follows:

$$ANP = \begin{pmatrix} Bank\_loans \\ Corporate\_bonds \\ Preferred\_stock \\ Common\_stock \end{pmatrix} = \begin{pmatrix} 0.342 \\ 0.227 \\ 0.242 \\ 0.189 \end{pmatrix}$$

4.4 Using the Goal Programming Model

The ANP weights of the four financing alternatives are employed to build a goal programming model to allocate the optional financing decisions. The ANP weights of the four alternatives can be used as the priorities in the GP model. Table 6 illustrates the limitations and requirements for the financing plan. In Table 6, X_1, X_2, X_3 and X_4 represent the amounts of bank loans, corporate bonds, preferred stock, and common stocks and retained earnings of the KI Company, respectively, after financing actions. The GP model formulation is built in Table 6, where d_i^+ and d_i^- are the negative and positive deviation variables, respectively. The lingo 10.0 is used for solving the GP model. The results are shown as follows:

$$\begin{aligned}
&X_1 = 3{,}330{,}800, \quad X_2 = 1{,}000{,}000, \quad X_3 = 1{,}699{,}200, \quad X_4 = 6{,}000{,}000, \\
&d_1^+ = d_1^- = d_2^+ = d_3^+ = d_4^+ = d_9^- = d_{10}^- = 0, \quad d_2^- = 6{,}806.80, \\
&d_3^- = 10{,}608, d_4^- = 0.01450607, \quad d_5^- = 1{,}199{,}200, \\
&d_6^- = 2{,}030{,}000, \quad d_7^- = 830{,}800, \\
&d_8^- = 2{,}030{,}000, \quad d_9^+ = 139{,}392, \quad d_{10}^+ = 0.01549393
\end{aligned}$$

The results of this integrated GDMS model show that the assumed KI Corporate should borrow \$830,800 (= 3,330,800–2,500,000) in bank loans and issue preferred stock of \$1,199,200 (= 1,699,200–500,000) to obtain the capital for investment projects. The total flotation cost for additional capital of \$23,193.20 is lower than the planned amount of \$30,000. After this financing decision, the financial situations of KI are changed as the long term liability ratio is 36 %, the weighted average capital cost is 11.5494 % and the total amount of interest expenditure is \$489,392. All of the financial data are compiled with this plan.

Let the illustration of KI Company be scenario 1. It takes three different sets of scenarios to verify the effectiveness of this GDMS model for financing decisions. Scenario 2 is the result of using the GP model without ANP weights. In Scenario 3, the decision makers prefer to issue common stock to raise capital (with ANP weights of 0.153, 0.297, 0.231 and 0.319). In scenario 4, the decision makers prefer to issue corporate bonds and preferred stock to raise capital (with ANP weights 0.250, 0.277, 0.247 and 0.226). The results of the four scenarios show that this integrated GDMS model for financing decisions is accurate in determining a suitable allocation of financing

Table 4 The weighted super matrix (partial results)

	A1	A2	A3	A4	C1	C2	C3	C4	C5	C6	C7	C8	Goal
A1	1.0000	0.0000	0.0000	0.0000	0.2176	0.0815	0.0336	0.0291	0.5584	0.3950	0.3178	0.3393	0.0000
A2	0.0000	1.0000	0.0000	0.0000	0.2153	0.2650	0.0516	0.0627	0.2398	0.3950	0.0609	0.4969	0.0000
A3	0.0000	0.0000	1.0000	0.0000	0.0320	0.0322	0.2350	0.1817	0.0572	0.0473	0.0262	0.0720	0.0000
A4	0.0000	0.0000	0.0000	1.0000	0.0351	0.1214	0.1799	0.2266	0.1447	0.1626	0.0951	0.0918	0.0000
C1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0523
C2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0738
C3	0.0000	0.0000	0.0000	0.0000	0.1667	0.1667	0.0714	0.1667	0.0000	0.0000	0.2500	0.0000	0.2220
C4	0.0000	0.0000	0.0000	0.0000	0.1667	0.1667	0.0714	0.0000	0.0000	0.0000	0.2500	0.0000	0.2584
C5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0714	0.1667	0.0000	0.0000	0.0000	0.0000	0.3007
C6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0303
C7	0.0000	0.0000	0.0000	0.0000	0.1667	0.1667	0.0714	0.1667	0.0000	0.0000	0.0000	0.0000	0.0318
C8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0307

Table 5 Limit matrix (partial results)

	A1	A2	A3	A4	C1	C2	C3	C4	C5	C6	C7	C8	Goal
A1	1.0000	0.0000	0.0000	0.0000	0.3593	0.2233	0.2000	0.2262	0.5584	0.3950	0.4244	0.3393	0.3419
A2	0.0000	1.0000	0.0000	0.0000	0.2969	0.3466	0.1851	0.1579	0.2398	0.3950	0.1467	0.4969	0.2270
A3	0.0000	0.0000	1.0000	0.0000	0.1607	0.1608	0.3224	0.2741	0.0572	0.0473	0.1753	0.0720	0.2420
A4	0.0000	0.0000	0.0000	1.0000	0.1831	0.2694	0.2925	0.3417	0.1447	0.1626	0.2537	0.0918	0.1891

Table 6 Combing with GP model formulation

GP model formulation	Goals
Minimize Z=	
$p_1(d_1^+ + d_2^+)$	Satisfy two mandated constrains
$p_2(d_3^+ + d_4^+)$	Select financing tools by composite importance weights
$p_3(0{,}342d_5^- + 0.227d_6^- + 0.242d_7^- + 0.189d_8^-)$	Avoid over planned and WACC
$p_4(d_9^+ + d_9^-)$	Avoid over/under planned interest expenditures
$p_5(d_{10}^+ + d_{10}^-)$	Avoid over/under planned WACC
Subject to:	
$\frac{x_1+x_2}{x_1+x_2+x_3+x_4} - d_1^+ + d_1^- = 36\,\%$	Avoid over the upper level of long term liability ratio
$13{,}000 + 0.8\,\% \times (x_2 - 1{,}000{,}000) + 0.85\,\% \times (x_3 - 500{,}000) + 1\,\% \times (x_4 - 6{,}000{,}000) - d_2^+ + d_2^- = 30{,}000$	Avoid over the total cost for financing plan $30,000
$8\,\% \times x_1 + 7\,\% \times x_2 + 9\,\% \times x_3 - d_3^+ + d_3^- = 500{,}000$	Avoid over the interest expenditures 500,000
$\frac{8\,\% \times x_1}{x_1+x_2+x_3+x_4} + \frac{7\,\% \times x_2}{x_1+x_2+x_3+x_4} + \frac{9\,\% \times x_3}{x_1+x_2+x_3+x_4} + \frac{15\,\% \times x_4}{x_1+x_2+x_3+x_4} - d_4^+ + d_4^- = 13\,\%$	Avoid over the upper level of planning WACC
$2{,}500{,}000 \le x_1$	The original amounts of bank loans
$1{,}000{,}000 \le x_2$	The original amounts of corporate bonds
$500{,}000 \le x_3$	The original amounts of issued preferred stock
$6{,}000{,}000 \le x_4$	The original amounts of issued common stock
$x_1 + d_5^- = 4{,}530{,}000$	The upper level amounts of bank loans
$x_2 + d_6^- = 3{,}030{,}000$	The upper level amounts of issuing corporate bonds
$x_3 + d_7^- = 2{,}530{,}000$	The upper level amounts of issuing preferred stock
$x_4 + d_8^- = 8{,}030{,}000$	The upper level amounts of issuing common stock
$x_1 + x_2 + x_3 + x_4 = 12{,}030{,}000$	The amounts of total assets
$8\,\% \times x_1 + 7\,\% \times x_2 + 9\,\% \times x_3 - d_9^+ + d_9^- = 350{,}000$	Avoiding over/ under planned interest expenditures
$\frac{8\,\% \times x_1}{x_1+x_2+x_3+x_4} + \frac{7\,\% \times x_2}{x_1+x_2+x_3+x_4} + \frac{9\,\% \times x_3}{x_1+x_2+x_3+x_4} + \frac{15\,\% \times x_4}{x_1+x_2+x_3+x_4} - d_{10}^+ + d_{10}^- = 10\,\%$	Avoiding over/ under planned WACC
$d_i^+, d_i^- \ge 0 (i = 1, 2, \ldots, 10)$	

solutions. Table 7 depicts the conditions, including the ANP weights of the allocated amounts of each alternative. It shows that different ANP weights may result in different satisfactory financing solutions.

Table 7 The data of different Scenarios

	Scenario 1 ANP weights (0,342, 0.227, 0.242, 0.189)	Scenario 2 Without ANP weights	Scenario 3 ANP weights (0.153 0.297, 0.231, 0.319)	Scenario 4 ANP weights (0.250, 0.277, 0.247, 0.226)
Bank loans	3,330,800	2,798,148	2,704,804	2,500,000
Corporate bonds	1,000,000	1,159,259	1,625,982	1,830,800
Preferred stock	1,699,200	500,000	500,000	1,699,200
Common stock	6,000,000	7,572,593	7,199,214	6,000,000
Total assets	12,030,000	12,030,000	12,030,000	12,030,000
Total liability	4,330,800	3,957,407	4,330,786	4,330,800
Long term liability ratio	36.0000 %	32.8962 %	35.99999 %	36.0000 %
Flotation cost	23,193.20	30,000	30,000	29,839.60
Interest expense	489,392	350,000	375,203	481,084
WACC	11.5494 %	12.3515 %	12.0955 %	11.4803 %

5 Discussion

As a result of this study, we propose an integrated GDMS model for the group financing decision making of a firm. The processes presented in the illustrated case represent an integrated GDMS model for gathering the group opinions of six financial managers and for considering the financing limitations of the financial requirements. By using the proposed model for the financing decision making, the group DMs can systematically consider the interdependent relationships of financial goals and requirements to obtain a satisfactory solution for their financing tools. This paper has shown the contribution of the integrated GDMS model combined with the ANP, DEMATEL and GP methods in solving problems associated with financing decision making. This GDMS model for structuring complex evaluation problems employs the ANP approach to structure the multi-criteria network process of financing decision problems, and then utilizes DEMATEL to identify the interdependent relationships of those criteria for evaluating the ANP priority weights. Finally, the GP method is employed to deal with the quantitative constraints on environment or finance to achieve a satisfactory solution.

In the past, financial theory has addressed the financing decision problems with very different perspectives, some of which included the characteristics of a firm, the size or age of a firm, the reputations of the firm and enterpriser, its debt capacity, financial flexibility, etc. Financing decision making is a complex group decision making and evaluation process. Using this integrated GDMS model forces financial managers to look for careful structuring of the financing decision problem before finding a solution for it.

Financing decision making is necessary for all companies or industries even though they may have different characteristics. Companies need a systematic framework to assist the group financing decision makers in evaluating both qualitative decision criteria and quantitative decision limitations in the evaluation process. The roles of qualitative criteria and quantitative constraints are often vital in financial decision making. The quantitative financing limitations include: the upper limit of debt ratio, interest

expenditures and costs of capital. This integrated GDMS model combines ANP with DEMATEL to deal with the interdependent relationships of qualitative decision criteria, and then the ANP priority weights of those criteria are obtained. Consequently, this model uses a goal programming model combined with ANP priority weights to deal with quantitative decision criteria and constraints, and then the final solution of alternatives selection is obtained. With this model, we can overcome the defect of most MCDM methods, such as ranking and AHP, that do not make any distinction between quantitative and qualitative criteria in the decision making process.

The structuring framework of multi-criteria financing problems is the focus of this integrated GDMS model. Through an iterative and interactive procedure of collecting group decision criteria, the common consensus of an organization can be achieved. It is a good model for gathering group opinions and reducing decision bias from a single or a few decision makers. It is also a very valuable tool for constructing an uncertain framework from an interdependent network structure. The integrated GDMS model can enhance transparency in the decision process and also generate good argumentation in the decision making.

Sophisticated and realistic scientific methods in the field of financing management are deficient. This research simultaneously considers criteria dependency as well as multiple financial objectives and constraints, and uses an objective method to determine whether the criteria are interdependent. Group DMs can apply this integrated model in financing decision making to reconcile conflicting financing criteria and limitations. Another advantage of this model is that it compares favorably with multivariate analyses and requirements.

6 Conclusions

A review of financial decision literature shows that current researchers seldom apply the integrated approach of DEMATEL, ANP and GP to financial decision making. This paper proposes an integrated GDMS model for solving financing decision making problems. It successfully integrates DEMATEL, ANP and GP to effectively deal with multi-criteria and network-related group decision problems in corporate financing. This model can support a corporate financing decision process by recommending either a matching strategy or a portfolio financing tool. This model has a promising future in the field of financial decision making and management since it offers a highly methodological and realistic framework to reconcile the conflicting financing goals and financial constraints by providing an integrated Group Decision Making Support (GDMS) model for corporate financing group decision makers (DMs). In addition, the integrated model proposed in this paper is sophisticated and captures a wider variety of factors in the area of financial decision making. However, the disadvantage of this model is that the success of using it depends heavily on the development of computerized multi-criteria decision support systems like Super Decisions software. Fortunately, the decision software is easily available and not costly.

Many financial institutions and most companies acknowledge that financial decision making problems involve multiple criteria and are multidimensional in nature. Group DMs must have a method for properly evaluating the interdependent relationships of

those criteria and dimensions, to realize the complex decision structure for selecting alternatives. This integrated GDMS model can overcome interdependent problems and obtain the priority weights by applying the DEMATEL and ANP approach. Furthermore, this model also combines optimization and mathematical approaches to address financing decision making. The optimization and mathematical software packages are easily available and are relatively cheap; this makes it relatively easy for decision makers to obtain satisfactory solutions.

In the real world, financing decision making problems do have complex interactions, so it is important to know how to structure and evaluate the interactive relationships. Another advantage of this integrated GDMS model is that it can be used to deal with and align with the interdependent relationships, as well as the constraints on the organizational environment. The importance of this integrated GDMS model for practicing managers is that an organization can identify the financing requirements and financial strategy, communicate and integrate inner opinions, and collect knowledge during the data evaluating process. Apart from its use in financial decision problems, this GDMS model can also can be applied to other multi-criteria decision making problems such as marketing mix and banking services. This integrated model addressing complex decision making problems is worth developing and promoting.

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