A Zero-one Goal Programming Model for Marketing Project Selection

0-1模型應用於行銷專案選擇

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Abstract

A zero-one goal programming (ZOGP) is an important technique for solving many real-world problems. This paper adopts the new approach to show how to program the ZOGP model to solving a decision / management problem. The decision model is developed as a binary goal programming model base on a case analysis. The overall objective is to design and evaluate a model for effective resource planning in a marketing activity projects selection process. The main contribution is in problem identification and development of the mathematical model for project selection. This ZOGP model facilitates decision-making (DM) planning process and managerial policy in resources distribute.

Keywords: Zero-one goal programming (ZOGP); Marketing activity; Decision-making; Project selection

摘要

0-1目標規劃為解決問題重要工具之一，本研究利用0-1目標規劃方法來處理行銷管理專案選擇，特別是在企業資源限制下如何選擇最佳的行銷活動專案。本文主要貢獻在於提出一個有效的數學模式，除行銷活動外本模型亦可用於解決任何管理專案選擇問題。

關鍵字: 目標規劃，行銷活動，決策，專案選擇
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I. Introduction

Selecting the right marketing project is a critical business activity that has been recognized and repeatedly emphasized by many researchers (Jiang, et al., 1997). Many examples exist in the practitioner press and academic literature that describe the applications of optimal selection process in the marketing function for decision marking in tactical and strategic situations (Li, 1995, Taylor, 1986, and Curry, 1993). Evidence for the adoption of goal programming (GP) in marketing practice is not only demonstrated by increased ZOGP applications but also increased ZOGP use by marketing managers. Meanwhile, Li, et al.’s (1993) studies reported that the marketing managers expressed dissatisfaction with marketing project information and the activities planning and selecting process. The marketing managers realize that control over the firm’s marketing resources is being lost.

Activity advances in the marketing strategy have impacted the customer, the producer and the customer-producer exchange mechanisms in product/service transactions. Thus, select the right marketing project is a critical business activity and is a difficult task. There are different goals to be achieved under the selection process. Selection of marketing activity project is complicated by the existence of multiple conflicting criteria. The decision-makers (DMs) to select or not to select of a project will depend on the perceived conflict between the benefit and risk of the total projects along with other criteria. The optimal selection process is a significant strategic resource allocation decision that can engage an organization in substantial long-term commitments (Santhanam & Kyparisis, 1996).

Several methods have been utilized in the marketing activity project selection decision. The goal programming is one of the models which have been developed to deal with the multi-objectives decision-marking (MODM) problems. The model allows taking into account simultaneously many objectives while the decision-marking is seeking the best solution from among a set of feasible solutions. GP was first introduced by Charnes and Cooper (1961), and further developed by Lee (1972), Ignizio (1985), Tamiz et al. (1998), Romero (2001), Chang (2004), among others. The technique of GP is to minimize the deviations among the non-achievement of the corresponding goals. It can be expressed as following model:

(1) GP model

\[
\text{Minimize } \sum_{i=1}^{n} |f_i(X) - g_i|
\]
Subject to \( X \in F \) (\( F \) is a feasible set),

where \( f_i(X) \) is the linear function of the \( i \)th goal, and \( g_i \) is the aspiration level of the \( i \)th goal.

The above minimization process can be accomplished with various methods such as lexicographic GP (LGP), MINMAX GP (MGP), weighted GP (WGP) (Romero, 2001), and mixed binary GP (MBGP) (Chang, 2004) are expressed as follows:

(2) LGP model

Let \( \min a = \left[ \sum_{i \in h_r} (\alpha_i d_i^+ + \beta_i d_i^-), \ldots, \sum_{i \in h_r} (\alpha_i d_i^+ + \beta_i d_i^-), \ldots, \sum_{i \in h_r} (\alpha_i d_i^+ + \beta_i d_i^-) \right] \)

Subject to \( f_i(X) - d_i^+ + d_i^- = g_i, \quad i = 1, 2, \ldots, n, \quad i \in h_r, \quad r = 1, 2, \ldots, Q. \)
\( d_i^+, d_i^- \geq 0, \quad i = 1, 2, \ldots, n, \)
\( X \in F \) (\( F \) is a feasible set),

where \( h_r \) represents the index set of goals placed in the \( r \)th priority level; \( \alpha_i \) and \( \beta_i \) are the respective positive weights attached to these deviations in the achievement function; \( d_i^+ \), and \( d_i^- \) are negative and positive deviations from target value of \( i \)th goal; \( f_i(X) \) and \( g_i \) are defined as in GP.

(3) MGP model

Minimize \( D \)
Subject to \( D \geq \alpha_i d_i^+ + \beta_i d_i^- \),
\( f_i(X) - d_i^+ + d_i^- = g_i, \quad i = 1, 2, \ldots, n, \)
\( d_i^+, d_i^- \geq 0, \quad i = 1, 2, \ldots, n, \)
\( X \in F \) (\( F \) is a feasible set),

where \( D \) is an extra continuous variable that measures the maximum deviation; other variables are defined as in LGP.

(4) WGP model

Minimize \( \sum_{i=1}^{n} (\alpha_i d_i^+ + \beta_i d_i^-) \)
Subject to \( f_i(X) - d_i^+ + d_i^- = g_i, \quad i = 1, 2, \ldots, n, \)
\( d_i^+, d_i^- \geq 0, \quad i = 1, 2, \ldots, n, \)
\( X \in F \) (\( F \) is a feasible set),

where all variables are defined as in LGP.
Li (1995) proposed an equivalent model to reduce the number of additional variables, and used in WGP, let $\alpha_i = 1$ and $\beta_i = 1$, get follows:

\[
\text{Minimize } \sum_{i=1}^{n} 2d_i - f_i(X) + g_i
\]

Subject to $- f_i(X) + d_i + g_i \geq 0$, $i = 1,2,\ldots,n$,

\[d_i \geq 0, \quad i = 1,2,\ldots,n,\]

\[X \in F \quad (F \text{ is a feasible set}),\]

where the positive deviation and negative of the $i$th goal are $d_i$ and $-f_i(X) + g_i$, respectively.

These approaches have been applied to solve many real-world problems (Tamiz et al., 1998), such as facility layout, optimal design, computer graphics, and even product cost problems (Chang, 2002). In order to solve a decision/management problem, which involved the achievement of goals, some of them are met and some are not met. This problem cannot be solved by current GP models Chang (2004). For this issue, Chang (2004) presented a MBGP method to solve the problems, and the approaches as follows:

(5) MBGP model

\[
\text{Minimize } \sum_{i=1}^{n} (d_i^+ + d_i^-)y_i
\]

Subject to $(f_i(X) - g_i)y_i = d_i^+ - d_i^-, \quad i = 1,2,\ldots,n$,

\[d_i^+, d_i^- \geq 0, \quad i = 1,2,\ldots,n,\]

\[y_i \in R_i, \quad i = 1,2,\ldots,n,\]

\[X \in F \quad (F \text{ is a feasible set}),\]

where $R_i$ is the environment constraint function of $i$th goal; $y_i$ is the binary variable of $i$th goal.

Although, many multi-criteria decision-making models have been developed to assist DMs in the information systems project selection process (Badri et al., 2001); for example, marketing project, no comprehensive model has yet been introduced that is simple to use and understand, and includes all the suggested factors that appeared in separate studies. In this paper, we attempt to overcome this shortcoming by including in a one model. The objective of this research is to establish a ZOGP model as an appropriate technique for marketing activity projects selection and implementing in a constrained resources environment.
II. A zero-one approach

A ZOGP is a mathematical programming approach to assign optimal values to a set of variables in the problems where there are multiple and conflicting goals, and measured in priority exists among the goals. A marketing activity project which explicitly incorporates all of the objectives that appeared in previous research. These factors include benefits, hardware, software and other costs, risk factors, preferences of DMs, completion time and training time constraints, cost of additional manpower required, mandated, mutually exclusive and contingency requirements (Badir et al., 2002). For reducing the number of additional variables, this paper will adopt some key factors to simplify the number of variable. Thus, based on the proposed MBGP method, this problem can be formulated as the following program:

\[
\text{(P 1)}
\]

Minimize \( z = \{ g_1(d_1^+, d_1^-), g_2(d_2^+, d_2^-), \ldots, g_n(d_n^+, d_n^-) \} \)

Subject to

\[
\sum_{j=1}^{n} c_{ij} y_j - g_i = d_i^+ - d_i^-, \quad i = 1, 2, \ldots, n,
\]

\[
y_j = 0, 1, \quad j = 1, 2, \ldots, n,
\]

where \( g_i \) is the aspiration level of the \( i \)th goal; \( d_i^+ \) and \( d_i^- \) are, respectively, over- and under-achievement of the \( i \)th goal; \( y_i \) is binary variable and \( c_{ij} \) represent the contribution of the project \( 1, 2, \ldots, n \).

III. The model

Assuming a food chain store company wants to select a new marketing activity projects for the marketing managers. The company has to compare with several projects and selecting most suitable projects having multi-criteria and achieved the organizational goals. From among 8 proposals, a set of projects had to be selected subject to the proposed budget constraints.

3.1. Decision variables

The variables are denoted as \( y_j \), where \( j = 1 \ldots n \), and they correspond to the \( n \) projects available for selection. It define \( y_j = 1 \) if project \( j \) is selected, and zero otherwise.

3.2. Benefit-related objective
In Eq. (1), is the benefit objective, which is to be maximized, represents the total benefit derived from the implemented projects.

$$\sum_{j=1}^{n} c_{ij}y_{j} - g_{1} = d_{1}^{+} - d_{1}^{-},$$

(1)

where \( g_{1} \) = benefit-related objective. Other variables are defined in P1.

### 3.3. Software and hardware cost-related objective

Software and hardware costs are two major factors in the marketing activities project selection process in marketing sector (Kotler & Keller, 2006). In other words, the resource of software, and hardware costs are also important budgeted. We include the two costs of software and hardware in the model as two objectives, which are to be minimized (see Eq. 2 and Eq. 3).

$$\sum_{j=1}^{n} c_{2j}y_{j} - g_{2} = d_{2}^{+} - d_{2}^{-},$$

(2)

$$\sum_{j=1}^{n} c_{3j}y_{j} - g_{3} = d_{3}^{+} - d_{3}^{-},$$

(3)

where \( g_{2} \) = software cost-related objective and \( g_{3} \) = hardware cost-related objective. Other variables are defined in P1.

### 3.4. Manpower required and other cost-related objectives

In addition, the other resource constraints it may be necessary to include in this case; such as manpower required and other cost-related objectives. Other studies reviewed did not include the two costs associated with the additional manpower cost and the other costs (for example, computer time, supplies consultancy fees, etc) required to implement some of the projects. It include the costs of these resources in the model as a cost related objective which is to be minimized; for examples, Eq. 4 and Eq. 5.

$$\sum_{j=1}^{n} c_{4j}y_{j} - g_{4} = d_{4}^{+} - d_{4}^{-},$$

(4)

$$\sum_{j=1}^{n} c_{5j}y_{j} - g_{5} = d_{5}^{+} - d_{5}^{-},$$

(5)

where \( g_{4} \) is manpower required and \( g_{5} \) is other cost-related objective. Other variables are defined in P1.

### 3.5. Preferences-levels objectives

Marketing activities project objectives operate through the needs, preferences, and
information requirements of marketing activities participator and DMs. A marketing message developed in response to this fact, therefore, generally realizes higher utilization levels, yields greater user satisfaction/appreciation (Jiang et al., 1997). This model an objective function with regard to preferences. Due to the nature of the projects, certain goals cannot be expressed in dollar amounts, in such case, each preferences levels can be scored or ranked and then include in MBGP model. In the scoring technique, the benefit arises from 1 to 10, with 1 indicating high preferences levels and 10 indicating low preferences levels. In Eq. (6), let $c_{61}$ to $c_{68}$ represent the scores of project 1 to 8 on the sixth goals (e.g., $g_6$). This goal can be represented in the model as:

$$\sum_{j=1}^{n} c_{6j} y_j - g_6 = d_6^+ - d_6^-,$$

where the right-hand side value of zero is an arbitrary chosen small number (Tripathy & Biswal, 2007), and $g_6$ are preferences levels. Other variables are defined in P1.

3.6. Completion and training time objectives

The completion time and training time as two constraints has been used in some studies (Badri et al., 2002). These two objectives are included to minimize the time required for projects completion, and are given by Eq. (7) and Eq. (8). For Eq. (8), nevertheless, DMs found the training time objective to be very important prior to the implementation phase. The estimated training times $c_{8j}$ for each project could be obtained from the vendors or the contractors of project software and hardware. With the same logic as in Eq. (8), the constraint equation could be rewrite as the following program:

$$\sum_{j=1}^{s} c_{8j} y_j - g_8 = d_8^+ - d_8^- = 0,$$

where the right-hand side could be set to zero, or the targeted time for training of the projects. The $g_7$ is completion time required, and $g_8$ is training time required. Other variables are defined in P1.

3.7. Mutually exclusive project
Some projects will be chosen if and only if they satisfy the resource constraints. Stewart (1991) suggested the use of mutually exclusive project, but did not include it into the model. For example, in a project $y_3$ and $y_5$ are mutually exclusive because they both required the use of the same resource (e.g., $y_3 + y_5 = 1$). Thus, the study allows some projects to be mutually exclusive and we write the corresponding constraints as in Eq. (9). In Eq. (9), only one of the two projects can be implemented (or both not implemented) for the condition to hold.

$$y_3 + y_5 = 1,$$  \hspace{1cm} (9)

3.8. Mandated project constraints

In addition to the other resource constraints it may be necessary to include constraints mandated by internal and external restrictions. For example, assume that project number 3 is mandated by firm’s policy and must be selected. The constraint $y_3 = 1$, is included in the model. Therefore, it writes the corresponding constraints as in Eq. (10).

$$y_3 = 1, \quad j = 1, 2, \ldots, n, \hspace{1cm} (10)$$

3.9. The objective function

The objective function, say $z$, will attempt to minimize the sum of positive and negative deviations associated with the constraints in following model.

$$\text{Minimize} \quad z = \sum_{i=1}^{8} (d_i^+ + d_i^-).$$  \hspace{1cm} (11)

IV. Computational results

When consider a 0-1 or BGP problem with the above goals and constraints (from Eq. (1) to Eq. (11), except Eq. (7) and Eq. (8)), which cannot be solved by current GP techniques (Chang, 2004). Table 1 provides the details of data with eight projects of corporate constraints. The values of preferences are taken using 1 to 10 scoring techniques. To get the preferences (see Eq. (6)), the DMs and marketing managers where asked to identify their preferences for each project by filling out a table containing all the selections. Table 2 provides data on the estimated benefit and the scores of DMs and users.
Table 1

Project towards resource utilization

<table>
<thead>
<tr>
<th>Project number</th>
<th>Software cost (NT$000)</th>
<th>Hardware cost (NT$000)</th>
<th>Manpower cost (NT$000)</th>
<th>Other cost (NT$000)</th>
<th>Completion time (days)</th>
<th>Training time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2250</td>
<td>2350</td>
<td>1050</td>
<td>480</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1150</td>
<td>2800</td>
<td>1400</td>
<td>370</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>900</td>
<td>1300</td>
<td>780</td>
<td>250</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1500</td>
<td>3160</td>
<td>1350</td>
<td>550</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>1880</td>
<td>2700</td>
<td>1250</td>
<td>340</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>780</td>
<td>1780</td>
<td>900</td>
<td>215</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>2610</td>
<td>3000</td>
<td>1600</td>
<td>530</td>
<td>23</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>750</td>
<td>2200</td>
<td>1100</td>
<td>420</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

*Budget requested software cost ($2,000,000), hardware cost ($3,500,000), manpower cost ($1,500,000), other cost ($600,000), and completion time (28 days).

Table 2

Benefit, mandated, preference of DMs and marketing managers

<table>
<thead>
<tr>
<th>Project number</th>
<th>Benefit ($000)</th>
<th>Mandated</th>
<th>Preference scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>180</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>190</td>
<td>No</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>245</td>
<td>Yes</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>350</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>260</td>
<td>No</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>215</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>320</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>280</td>
<td>No</td>
<td>2</td>
</tr>
</tbody>
</table>

This problem is solved using LINGO (Schrage, 1999) to obtain the optimal solutions as

\[(y_1, y_2, y_3, y_4, y_5, y_6, y_7, y_8) = (0, 0, 1, 0, 0, 0, 0, 1).\]

The model result is present in Table 3. This projects selected under this scenarios are 3 and 8.

V. Conclusion

A ZOGP problem is developed in this paper. The proposed approach can be easily applied to decision / management problems, which involved the achievement of goals, some of them are met or not met. Project selection is major component of effective marketing activities management. It helps in selecting projects when a number of promising alternatives exists, the challenge in carrying out this task with the budget constraints, time constraints and a limited number of human resources and facilities, etc.
The ZOGP provides an integrated framework to select a set of projects (e.g., marketing activity projects) that are consistent with the goals of the company. So the food chain store company has to select projects number 3, and 8 to achieved best choice as per the company goals; in which project 8 > project 3 (see Table 3).

While the case presented in this paper is in the domain of marketing projects selection, we provide an approach to better understand the nature of trade-off between the various components that affect the choice of projects for DMs. In the future, the model can be applied to any project selection situation in other fields, such as supplier, location setting, and marketing investment strategy selection, to help managers make an appropriate decision.

<table>
<thead>
<tr>
<th>Project number</th>
<th>Solution</th>
<th>Positive achieve ($d_i^+$)</th>
<th>Negative achieve ($d_i^-$)</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>350</td>
<td>0</td>
<td>350</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>380</td>
<td>380</td>
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<td>0</td>
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<td>7</td>
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<td>7</td>
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VI. References


