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Operational budgeting using fuzzy goal programming

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C H R O N I C L E

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A B S T R A C T

Having an efficient budget normally has different advantages such as measuring the performance of various organizations, setting appropriate targets and promoting managers based on their achievements. However, any budgeting planning requires prediction of different cost components. There are various methods for budgeting planning such as incremental budgeting, program budgeting, zero based budgeting and performance budgeting. In this paper, we present a fuzzy goal programming to estimate operational budget. The proposed model uses fuzzy triangular as well as interval number to estimate budgeting expenses. The proposed study of this paper is implemented for a real-world case study in province of Qom, Iran and the results are analyzed.

1. Introduction

One of the primary concerns among most governmental agencies is to have appropriate budget approved as early as the beginning of each fiscal year. A good operating budget motivates managers to do their best to reach their objectives while an inappropriate budget could virtually hurt managers' motivations. There are many studies for budgeting planning by considering different objectives, which may often be in conflict. Guilding (2003) performed an empirical survey and reported that capital budgeting systems in hotels operating under a divorced owner/operator structure could provide more formalization and a bigger propensity for investment proposal cash forecast biasing. Zhang et al. (2011) discussed the multinational capital budgeting problem to choose appropriate project where there were some candidate foreign projects. In their work, special cash flows and value sources of foreign projects were investigated. The work proposed one new uncertain zero–one integer model for optimal multinational project selection and to handle the resulted problem, a hybrid intelligent algorithm integrating the 99 Methods and genetic algorithm was provided. Libby and Lindsay (2010) presented the results of two surveys of mid- to large-sized North-American organizations to update the literature on North-American budgeting practices, to collect empirical

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evidence to evaluate the criticisms, and to start to detect strong tendencies or patterns in budgeting practice to inform future academic research. They reported that the majority of companies that budgets continue to apply for control purposes. Roper and Ruckes (2012) analyzed the optimal capital budgeting mechanism when divisional managers were privately informed about the arrival of future investment projects. Uyar and Bilgin (2011) explored budgeting practices of Turkish hotels in the Antalya region and reported that having a budget committee and budget manual are common for Turkish hotels. Kalu (1999) presented an extended goal programming methodology to describe the problem of capital budgeting under uncertainty to overcome the defects of chance-constrained capital budgeting models. More specifically, since financial planners frequently deal with the complex problem of capital budgeting by aggregating large numbers of small investment proposals into families of large projects, Kalu (1999) presented necessary and sufficient conditions for the acceptance of a set of investment projects by a business enterprise. The author indicated that under uncertainty, firms could face with capital rationing were less economically efficient than others. The author also reported that optimal allocation policy under uncertainty needs the actual discount rate to be bigger than the market cost of capital, a finding which is consistent with corporate finance practice. Bourmistrov and Kaarbøe (2013) explored how change in the design principles of management control systems (MCSs) based on using the beyond budgeting (BB) ideas has impacted the transition of decision-makers from "comfort" to "stretch" zones and how this transition changed the supply of and demand for managerial information. They explained how the implementation of new information provided by the MCS design, which is based on new principles, move decision-makers into the "stretch zone" characterized by new characteristics of decision-makers' mindset and behavior.

2. The proposed model

In this paper, we present a mathematical model based on fuzzy goal programming (Ignizio, 1976; Lee, 1972) for operational budgeting planning. Goal programming is one of the most popular techniques for handling various objectives in different levels. In goal programming, there are two kinds of constraints of hard and soft. The hard constraints are the same as the traditional constraints used in linear programming where the equality constraints must be satisfied and the inequality constraints are handled using slack/surplus variables. The soft constrains are other groups of constraints where we allow some deviation either positively or negatively. Any soft constraint must be handled using two variables of positive (d_i^+) and negative deviations (d_i^-). These two constraints are normally considered in the objective functions and the primary goal is to optimize deviation from desirable value.

2.1. Fuzzy programming

Zimmermann (1978) is believed to be one of the pioneers to develop fuzzy programming for the following mathematical programming,

$$\begin{aligned}
&\min Z(x) = \left[z_1(x), \cdots, z_k(x)\right] \\
&\text{subject to} \\
&g_i(x) \le b_i, i = 1, \cdots, m \\
&x \ge 0.
\end{aligned} \tag{1}$$

In order to solve this problem, we use the following steps,

Step 1. Solve model (1) *k* different times where each time by considering one objective each time.

Step 2. Setup the following ideal matrix based on *k* different solutions obtained from Step 1.

Table 1
Productivity matrix

	$Z_1(x)$	$Z_2(x)$	$\cdots$	$Z_k(x)$
x^1	$Z_1^*(x^1)$	$Z_2^*(x^1)$	$\cdots$	$Z_k^*(x^1)$
x^2	$Z_1^*(x^2)$	$Z_2^*(x^2)$	$\cdots$	$Z_k^*(x^2)$
$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$
x^k	$Z_1^*(x^k)$	$Z_2^*(x^k)$	$\cdots$	$Z_k^*(x^k)$

Step 3. Compute the lower bound l_i and upper bound u_i for each objective function as follows,

$$u_i = \max\left\{z_i(x^1),\cdots,z_i(x^k)\right\}; i=1,\cdots,k$$
$$l_i = \min\left\{z_i(x^1),\cdots,z_i(x^k)\right\}; i=1,\cdots,k$$

Step 4. Define a membership function, for instance

$$\mu(Z_i(x)) = \begin{cases} 0 & \text{if} \quad Z_i(x) \ge u_i \\ d_i(x) & \text{if} \quad l_i \le Z_i \le u_i \\ 1 & \text{if} \quad Z_i(x) \le l_i \end{cases}$$

where $d_i(x) = \dfrac{u_i - z_i}{u_i - l_i}$.

Step 4. Calculate β_i as the ratio of ith objective function, which represent how far the ith objective is from the ideal value as follows,

$$\beta_i = \min\left(\mu(Z_1),\cdots,\mu(Z_k)\right) \le \mu(Z_i).$$

Therefore, we have,

$$\max P = \sum_{i=1}^{k} w_i.\beta_i$$

subject to

$$\beta_i \le d_i; i=1,\cdots,k$$

$$g_j(x) \le b_j; j=1,\cdots,m \tag{2}$$

$$\sum_{i=1}^{k} w_i = 1$$

$$x_i \ge 0, 0 \le \beta_i \le 1$$

In problem (2), P=0 means that the model could not reach its desirable value and P=1 means it could reach its desirable value.

3. Case study

The proposed model of this paper has been applied for a real-world case study of operating budgeting in city of Qom, Iran. There are different budgeting chapters and we need to rank them in terms of their relative importance. The proposed model uses analytical network process (ANP) for ranking various items. Saaty (1999, 2004) has introduced various kinds of ANP techniques, such as the Hamburger Model, the Car Purchase BCR model, and the National Missile Defense model. The proposed model of this paper applies a modified Feedback System model (Fig. 1) that permits inner dependences within the criteria cluster, where the looped are signifies the inner dependences.

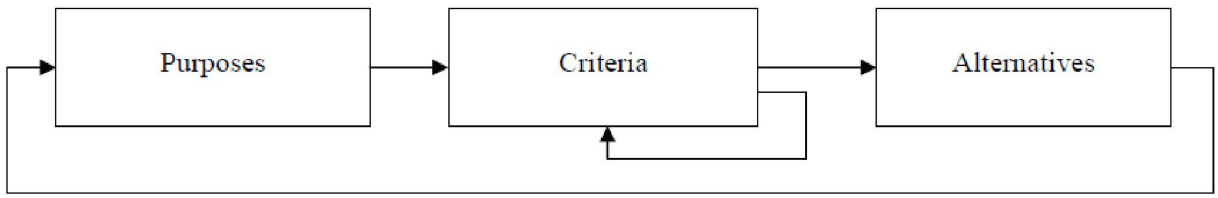

Fig.1. Feedback system model

To estimate the relative importance among various elements, all decision makers are invited to depend on a series of pair-wise comparisons and they are based on the Saaty's nine-point scale 1-9 and to evaluate the weights of elements. Table 2 demonstrates the results of our findings.

Table 2
The summary of ranking various budgeting chapters based on ANP method

Chapter	Weight	Chapter	Weight
General	0.04981	Sport	0.063927
Juridical	0.041364	Agriculture and natural resources	0.065996
Technical, financial	0.010178	Water resources	0.058789
Information technology	0.030162	Mining and industry	0.059056
Defence	0.00674	Environment	0.033365
Security	0.007674	Cooperation and trade	0.058322
Education	0.021687	Energy	0.040038
Art and Entertainment	0.066263	Transportation	0.061792
Healthcare	0.102363	Telecommunication	0.039838
Social security	0.065862	Real state	0.116777

Next, we are supposed to setup some targets and assign some values either deterministically or in terms of fuzzy numbers. Table 3 demonstrates the summary of our survey.

Table 3
The summary of targets for 20 different chapters

Chapter	Nature	Goal	Chapter	Nature	Weight
General	Deterministic	15000	Sport	Interval	(68000-74000)
Juridical	Deterministic	52500	Agriculture and natural resources	Fuzzy	(58000-60000-62000)
Technical, financial	Deterministic	6150	Water resources	Fuzzy	(58000-60000-62000)
Information technology	Deterministic	22500	Mining and industry	Fuzzy	(140000-142500-145000)
Defence	Deterministic	7500	Environment	Fuzzy	(2000-2250-2500)
Security	Interval	(6000-9000)	Cooperation and trade	Fuzzy	(1250-1500-1750)
Education	Interval	(200000-205000)	Energy	Fuzzy	(700-750-800)
Art and Entertainment	Interval	(17000-18000)	Transportation	Fuzzy	(80000-82500-85000)
Healthcare	Interval	(50000-60000)	Telecommunication	Fuzzy	(14000-15000-16000)
Social security	Interval	(67000-68000)	Real state	Fuzzy	(625000-630000-635000)

We have implemented the proposed model described earlier and Table 4 summarizes the results of our survey.

Table 4
The results of allocating different budgets by considering various alpha cut

Chapter	α=0.25	α=0.50	α=0.75
General	[10000,10000]	[10000,10000]	[10000,10000]
Juridical	[35000,40000]	[36000,38000]	[36000,37000]
Technical, financial	[4100,4100]	[4100,4100]	[4100,4100]
Information technology	[15000,22500]	[17000,20000]	[18000,19000]
Defence	[5000,5000]	[5000,5000]	[5000,5000]
Security	[5000,6000]	[5000,6000]	[5000,6000]
Education	[141130,200000]	[141630,200000]	[141930,200000]
Art and Entertainment	[12000,18000]	[13500,16500]	[15000,15000]
Healthcare	[50000,50000]	[50000,50000]	[50000,50000]
Social security	[40000,67000]	[40000,67000]	[40000,67000]
Sport	[48000,60000]	[50000,58000]	[52000,56000]
Agriculture and natural resources	[62351 ,55433]	[57348,61389]	[59226,60073]
Water resources	[59500,59500]	[59500,59500]	[59500,59500]
Mining and industry	[140000,141875]	[141000,142875]	[142000,143875]
Environment	[1500,1500]	[1500,1500]	[1500,1500]
Cooperation and trade	[1437,1437]	[1528,1528]	[1702,1702]
Energy	[400,800]	[450,750]	[500,700]
Transportation	[81875,81875]	[81875,81875]	[81875,81875]
Telecommunication	[1000,14000]	[1000,14000]	[1000,14000]
Real state	[628750,630650]	[629400,631700]	[630250,632850]

As we can observe from the results of Table 4, real state has received the highest operating budget followed by education, mining and industry. The results are presented in an interval forms so that it would give more flexibility for relocation of budget from one chapter into another one. This would help better management of budget and measuring the performance of various sectors, more accurately.

4. Conclusion

In this paper, we have presented an empirical investigation to assign appropriate budgets for various chapters in a real-world case study. The proposed study has applied interval data as well as fuzzy numbers to handle uncertainty in different chapters. Analytical network process has also been implemented to find appropriate weights for various chapters and using goal programming technique we have allocated desirable values in interval forms. The proposed model of this paper can be extended using other multi-criteria decision making such as Lp-norm, Lexicography, etc. and we leave it for interested researchers as future works.

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