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THE TARGET COSTING APPROACH IN MULTI-CRITERIA PROJECT BIDDING

INTRODUCTION

The main purpose of this paper is an experiment of modeling the project bid preparation by a single bidder using a method recently employed in new product development (NPD). The Target Costing method (TC) had been compiled in the 1980s in Japan as a planning tool to improve the NPD process in Toyota Corp. Its main goal was to aid in the preparation of the offer which will be evaluated by an assumed customer with respect to more than one criterion with simultaneous pursuance to achieving his or her own profits. Both the results achieved thanks to its application in early initiations and a fast growing number of companies exploiting this method argue that it is a good tool for multi-criteria planning of NPD in a competitive environment. The author of the paper proposes the introduction of TC approach to planning process of a project meant as a service rather than a product. The project bidding process is investigated as the main field of its application in project planning. In Chapter 1 the project bidding procedures are described in the perspective of multi-criteria decision analysis, and in Chapter 2 two recent approaches are invoked. Chapter 3 contains a proposal of TC combined with goal programming optimization model application in the given decision making problem.

1. PROJECT BIDDING

Nowadays, most of enterprises are delivered as projects, defined [7] as an intentional transformation of a system Ω from an initial state s to a specific state s'; therefore, s' should represent the goals to be achieved. As in every system in a project at the level of planning each evaluation should consider multiple objects and relations between them. Because of that several project characteristics depends on others. A common example is the time-cost trade-off where project completion time and realization cost are examined. Usually faster completion of several activities in the course of the entire project completion involves higher costs and vice versa. In every project it is usually necessary to evaluate more than two main criteria. In different applications their number rises depending on the specific criteria important in particular branches. Their number and character depend only on the evaluator. The most important feature of a project is its uniqueness which means that there was no identical project done the same way before. Even if several projects are similar in their scope, the conditions of their realization are usually different, so that the past data can't be sufficient for the planning of a new project. With uncertainty in estimations of future conditions this is the main source of risk in every planned project.

This paper emphasizes one specific case in which the project will be realized for an external (outside the company) owner. The project owner can choose a contractor from among several competing providers. In such situation the goals for each provider (bidder) are:

- to win the bidding,
- to achieve profits from the realization in case of winning.

The project owner can evaluate bids and chose the best one with respect to his criteria mostly by means of one of the following procedures or by their combination:

- price enquiry (e.g. different providers offer the same product, but with different prices) or other single-criterion enquiry,
- limited tender – multi-criteria analysis where only the authorized providers' bids are examined,
- unlimited tender, where every bid is examined, no matter who the provider is,
- negotiations (the best bid is negotiated with providers),
- full liberty order (the best bid is chosen without restrictions: any criterion matters),

In the present paper the discussion will be constrained to unlimited tender procedure, whose scheme is shown in Figure 1.

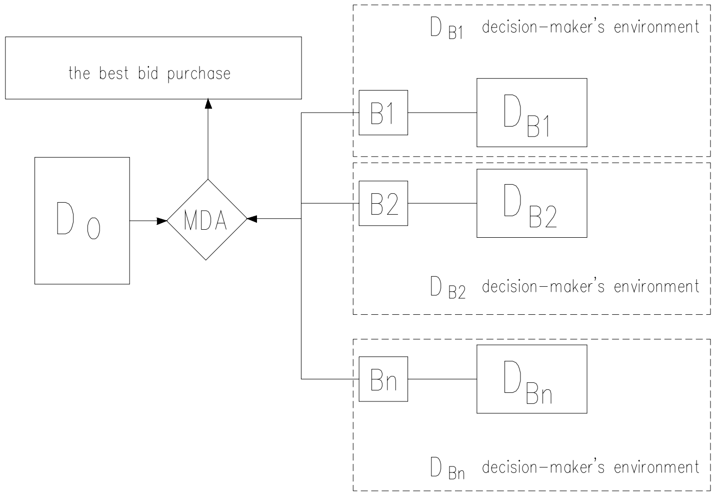

Fig. 1. Unlimited tender procedure

The main features of unlimited tender are:

– every bidder knows the criteria and procedure of examination while preparing bids,
– there is no information flow between decision-makers and bidders,
– every bid must meet the deadline,
– subjects of all bids are undisclosed until their simultaneous disclosure.

In such situation every individual bidder is treated equally: nobody is favored. Competitors don't know the number of competitive bids, the identity of the bidder, or the contents of the bids.

In such situation there is a recognized additional source of risk – the uncertainty of the outcome of the bidding competition. If a bidder has a full knowledge about other bidders, he can compare his own bid with all others, estimate the probability of winning, recognize his own strengths and weaknesses and reformulate the bid if necessary. Unfortunately in most cases such knowledge is limited. In the tender procedure, however, only the best bid will be awarded. For every single bidder this means that his offer must be better than the best of the other offers. Therefore there should be enough information to compare one's own bid with the expected best bid content. In the following sections two recent methods aiding bid preparation are presented. The first could be used in project bidding strategy planning; the second is useful for estimating the completion progress and due date after the bidding competition has been won. The third method presented here is a new proposal allowing the bidder to plan the whole bid, including the schedule before laying down the bids.

2. MULTI-CRITERIA PROJECT BIDDING – RECENT RESEARCHES

AHP based models

A possibility of using the Analytic Hierarchy Process (AHP) in project bidding was described by, Cagno, Caron and Perego [2]. Their paper shows the combined AHP and simulation model helping the individual bidder to define the bidding strategy. In their approach a basic knowledge of competitors is necessary, because every bid is compared with the others. The authors suggest planning the bid with respect to technical, financial, service, and contr-actual considerations and calculating its competitive value by assigning certain evaluation criteria and expected competitive bids to the project owner. Using this value the probability (P_{WIN}) of winning the bidding could be estimated. Knowing the price P and the estimated profit calculated on the basis of estimated costs C the authors obtained the expected bid profit contribution ($EPC = P_{WIN}(P - C)$). If this value is acceptable for the bidder, the bid can be offered. Otherwise, creating a new bid and repeating the analysis is suggested. The general algorithm of this approach is shown in Figure 2:

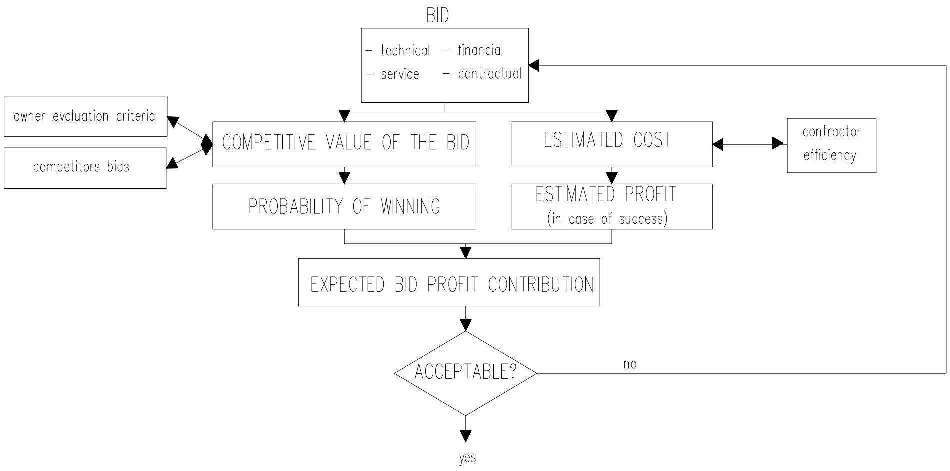

Fig. 2. Decision framework for AHP based model [2]

Further considerations show the effort of modeling the comparisons of several criteria between one's own bid and that of the competitors. There the AHP is used to calculate the priorities of each alternative for each criterion. Using a Monte Carlo simulation the authors obtained a distribution of priorities of final bids (which represents the competitive value of the bids); this way the comparison of one's own bid with competitive bids is achieved.

The Elmaghraby's approach

Elmaghraby [5] emphasizes the bidders' expectations in case of successful completion of bidding. His discussion refers to internal conditions of the company. It is assumed that the cost of project must be equal to total planned cost of its realization multiplied by *FaRM* (*Fair and Reasonable Markup*).

The idea of FaRM (which is exactly a factor that ensures the expected rate of return) came from bi-criteria time-cost trade-off in a project. It is also an attempt to allocate value of money changing in a time interval. To calculate the *FaRM* value it is necessary to identify the *key events* (*KE*) in the plan of the project. Key events are events whose appearance means that a part of work has been completed when a partial payment is requested. A special kind of *KE*s in every project are the last events. Favoring of *KE*s is necessary to identify cash flows (inflows and outflows) in a project and to assign them to the appropriate graph nodes. *KE* nodes are the last ones in subgraphs shares activities required to complete a part of a project. Further discussion could be conducted for the deterministic (based on a Critical Path Method) or the probabilistic (PERT) case. In both situations dues in every *KE*s are calculated as a sum of costs of completing shared activities increased by *FaRM.* In the deterministic case *FaRM* has the value $(1 + p)\alpha$, where p is the required profit of the contractor and α is a discounting factor complying money losing in value during realization of the part of project under consideration. The probabilistic case is somewhat more complex and requires the compliance of probabilities of completing several events at specified dates using mean time values of its predecessors.

The approach described above is not a complex solution for the project bidding problem. It does not comply with the requirement of choice of alternative by the customer. The financial flows are as a matter of fact the main factors in achieving profits but the choice of the objective bid is the necessary condition for further analysis.

3. TARGET COSTING WITH GOAL PROGRAMMING MODEL

In TC method a new way of price estimation was developed. The difference between this one and the classical one was that the price P (defined by marketing research) was an initial information from which the acceptable cost K^p of the production was calculated. The expected profit Z can be used to calculate K^p.

$$K^p = P - Z \tag{1}$$

In this approach the product can be treated as a set of n components, which are carriers of m consumer-evaluated attributes J_j $(j = 1,...,m)$. Usually the present costs of all components (also named *drifting costs* – k_i^D) summarized to form the global drifting cost K^D:

$$K^D = \sum_{i=1}^{n} k_i^D \tag{2}$$

is higher than the acceptable cost K_p.

A model described by Kuchta [6] and modified by Błaszczyk [1] is based on the matrix M:

$$M = \begin{pmatrix} v_{11} & \cdots & v_{1m} \\ v_{n1} & \cdots & v_{n} \end{pmatrix} = \begin{pmatrix} f_{11} g_1 & \cdots & f_{1m} g_m \\ f_{n1} g_1 & \cdots & f_{nm} g_m \end{pmatrix} \tag{3}$$

where f_{ij} ($\sum_i f_{ij} = 1$) are estimated contributions of the component i ($i = 1,...,n$) in the whole project attribute j and g_j ($\sum_j g_j = 1,\ j = 1,...,m$) are weights representing the contribution of the attribute j in clients' expectations. The values v_{ij} are products of contributions f_{ij} multiplied by g_j for each component for each attribute weight. For each component i we can calculate its value of the utility evaluation function U_i, based on a function Y_i used by the customer to evaluate bids. In general, U_i can be written as follows:

$$U_i = Y_i(v_{ij}) \tag{4}$$

Referring k_i^D for each component to global value K^D, a relative drifting cost k_i^{D*} can be obtained:

$$k_i^{D*} = \frac{k_i^D}{K^D} \tag{5}$$

and the relation Z_i:

$$Z_i = \frac{U_i}{k_i^{D*}} \tag{6}$$

gives the information about the actual cost of each component compared to its utility for the client. Three cases are possible:

a) $Z_i = 1$ – ideal case, cost of component is adequate to its evaluation value, no modifications are expected,
b) $Z_i > 1$ – advantageous case, its evaluation value is disproportionately high,
c) $Z_i < 1$ – disadvantageous case, drifting cost is too high relative to its evaluation value, component costs need to be lowered.

In case of overdraft:

$$K_p < K^D \tag{7}$$

the improvement of the utility can be reached by modification of attributes in components, where $Z_i < 1$ to increase its value in clients' eyes. In other cases such operation is not feasible. The drifting cost reduction of those components is required to reach the level of acceptable cost. In the case where cost reduction is not feasible it is necessary to revise the value of the expected profit. If the expected profit has to be lowered below its minimal value, it may be suggested that further bid preparation be abandoned. The general scheme of target costing algorithm is shown in Figure 3:

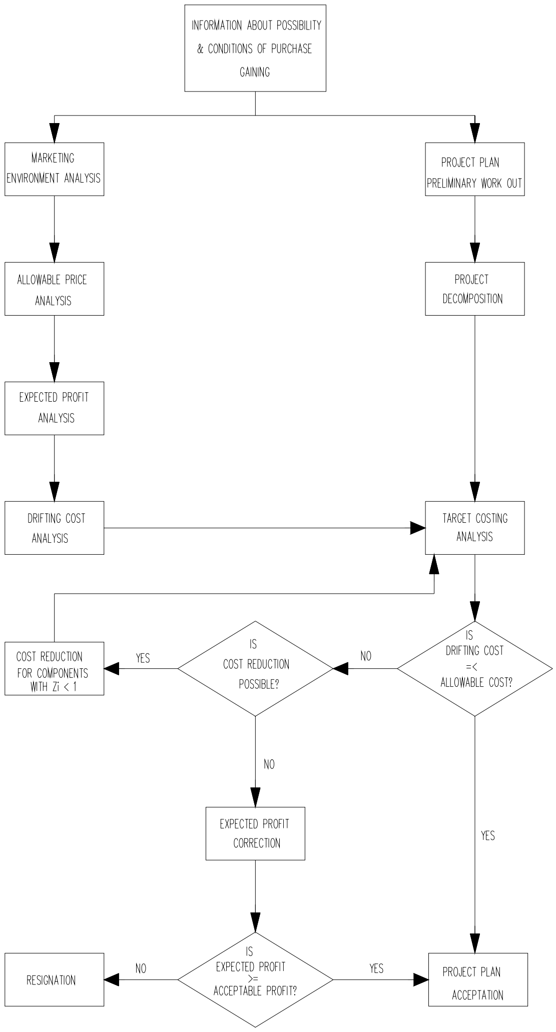

Fig. 3. Decision algorithm scheme for project bid preparation with target costing [1]

In the paper [1] an improvement of the target costing method in project planning is suggested by introducing the *goal programming* (*GP*) algorithm [3]. The idea of GP is to replace multiple criteria by a single metacriterion. The goal of each criterion can be represented by a single point or an interval; the objective function is a minimized sum of weighted lower and upper deviations. In the target costing approach we have multiple goals according to the number of project components. In an ideal situation $Z_i = 1$ for every component. The use of the GP procedure makes it possible to measure every deviation Z_i, both "z_i^+ – *in plus*" and "z_i^- –*in minus*":

$$z_i^+ = \begin{cases} Z_i - 1, & \text{for} \quad Z_i > 1 \\ 0, & \text{for} \quad Z_i \le 1 \end{cases} \tag{8}$$

$$z_i^- = \begin{cases} 0, & \text{for} \quad Z_i > 1 \\ 1 - Z_i, & \text{for} \quad Z_i \le 1 \end{cases} \tag{9}$$

The objective function could be defined as follows:

$$\sum_{i=1}^{n} (w_i^+ z_i^+ + w_i^- z_i^-) \to \min \tag{10}$$

where:

w_i^+ – relative weight of z_i^+,
w_i^- – relative weight of z_i^-.

while:

$$Z_i + z_i^+ - z_i^- = 1$$

and:

$$Z_i = \frac{\sum_{j=1}^{m} v_{ij}(x_1^{(i)}, \ldots, x_{l_i}^{(i)})}{k_i^{D*}(x_1^{(i)}, \ldots, x_{l_i}^{(i)})}$$

with constraints:

$$\forall_i \forall_k \quad 0 \le x_l^{(i)} \le \overline{x}_l^{(i)}$$

where:

$i = (1, 2, ..., n)$, $j = (1, 2, ..., m)$, $l = (1, 2, ..., l_i)$,
n – number of activities i project,
m – number of evaluated criteria,
li – number of decision variables related to activity i,
$x_l^{(i)}$ – value of 1 variable related to activity I,
$\overline{x}_l^{(i)}$ – maximal value of l variable related to activity *I*.

Example

The project company is preparing a project realization bid for an external customer. The bid specifications include: detailed project scope, earliest time of the beginning of completion, required quality and quantity standards (described in the attached technical documentation), and bidding procedure description. The project scope contains seven activities $A_1, A_2,..., A_7$. The relationships between them are shown by the project network in Figure 4.

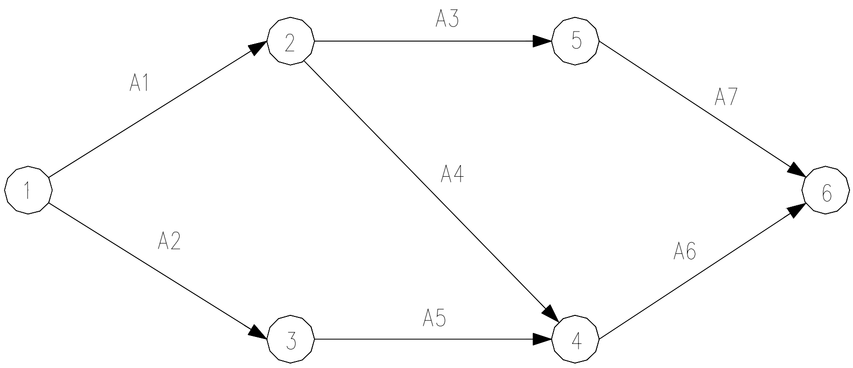

Fig. 4. Example of a project network

Bids will be evaluated with respect to two criteria: *time (date of project completion) T* and *price P.* Weights w_T i w_P are equal to 50%. The chosen bid will be characterized by the lowest value of the following evaluation function:

$$Y = w_T \frac{T_{oi}}{T_B} + w_P \frac{P_{oi}}{P_B} \rightarrow \min,$$

where, by analogy to the formula (1):

T_{oi}, P_{oi} – values of criteria T, P in the bid,
T_B, P_B – estimated best T, P values in all bids.

The decision maker assumes that the situation in which for any component i we have $Z_i > 1$ is much better than that in which $Z_i < 1$. For that reason, the weights are set to $w^+ = 0.9$ and $w^- = 0.1$.

As the components of the project, activities $A_1,..., A_7$, characterized by the completion times t and the completion costs c, were adopted. The quantity of profit also has the status of a component but with time value equal to the constant 0.

Based on competitive environment analysis it was found that the shortest possible completion time in other bids will be at least 32 days and the lowest price, at least \$1400. One's own possibilities are compared in Table 1:

Table 1

Drifting values of time and cost and possible compression of activities

Activity	„Drifting" time	Possible compression	„Drifting" cost	Compression cost per day
A_1	10	2	100	5
A_2	12	3	150	5
A_3	15	5	190	5
A_4	20	6	215	5
A_5	17	3	180	5
A_6	10	2	110	5
A_7	23	7	225	5

The expected profit was set on the level of \$150. The columns „drifting time" and „drifting cost" refer to the values of the completion times and the corresponding cost of activities reachable at the present time. The column „possible compression" defines the maximal time compression of activities (in days) and „compression cost per day" denotes the quantity of the additional cost (in \$) of the single day of compression.

To solve this model the Microsoft Excel with SOLVER was used. The recognized critical path consists of activities: A_1-A_3-A_7, with completion time 39 days. Drifting cost of project is calculated as follows:

$$K^D = \sum_{i=1}^{n} k_i^D = 100 + 150 + 190 + 215 + 180 + 110 + 225 = 1170$$

and the project price is equal to:

$$P = K^D + Z = 1170 + 200 = 1370$$

which makes the bid evaluation function value equal to:

$$Y = w_T \frac{T_{oi}}{T_B} + w_P \frac{P_{oi}}{P_B} = 0.5\frac{48}{32} + 0.5\frac{1370}{1400} = 1.099,$$

with the estimated best possible bid evaluation function value:

$$Y_B = w_T \frac{T_B}{T_B} + w_P \frac{P_B}{P_B} = 0.5\frac{32}{32} + 0.5\frac{1400}{1400} = 1.000,$$

Relative utilities of each activities are shown in Table 2:

Table 2

Relative evaluation values in first iteration

Component	Time		Cost		Z_i
	no weight	V_{iT}	No weight	k_i^{D*}	
A_1	0.21	0.1	0.07	0.04	2.85
A_2	0	0	0.11	0.05	0
A_3	0.31	0.16	0.14	0.07	2.25
A_4	0	0	0.16	0.08	0
A_5	0	0	0.13	0.07	0
A_6	0	0	0.08	0.04	0
A_7	0.48	0.24	0.16	0.08	2.91
zysk	0	0	0.15	0.07	0

The above results could be commented upon as follows: Z_i of critical activities are > 1, because its completion has a direct influence on the entire project realization time evaluated with respect to the *time* criterion. Non-critical activities do not change the project completion time – they are „useless" from this point of view, but their realization generate costs charging the *price* criterion. Therefore in those cases the values Z_i are equal to 0. A similar situation takes place as regards the *profit* component.

Thanks to the introduction of formulas (2)-(10) to the model, the following values were obtained:

Table 3

Activity completion times after analysis

Activity	Primary „drifting" time	Time after compression	Total cost of activity
A_1	10	8.00	110.00
A_2	12	9.10	164.50
A_3	15	11.91	205.47
A_4	20	15.10	239.50
A_5	17	14.10	194.50
A_6	10	8.10	119.50
A_7	23	16.17	259.17

This caused the change of the critical path: now it is A_1-A_4-A_6, with completion time 31.2 day and the drifting cost of the project equal to:

$$K^D = \sum_{i=1}^{n} k_i^D = 110 + 164.5 + 205.47 + 239.5 + 194.5 + 119.5 + 259.17 =$$

$$= 1292.64$$

and the project price can be calculated as follows:

$$P = K^D + Z = 1294.64 + 150 = 1442.64$$

which gives the following bid evaluation function value:

$$Y = w_T \frac{T_{oi}}{T_B} + w_P \frac{P_{oi}}{P_B} = 0.5 \frac{31,2}{32} + 0.5 \frac{1442,64}{1400} = 0.9604.$$

This indicates the growth of the total project utility and an increase of the possibility of winning the bidding. Moreover, the project evaluation fuction value lowered to the value $Y = 0.9604$, better than the estimated best bid value ($Y = 1.000$).

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