Implementation of Target Costing System Based on Net Present Value in a Fuzzy environment

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Abstract

Target costing (TC) is defined as a systematic process of managing product costs during the design stage of a new product, establishing market sales prices, and target profit margins as well as reducing the overall cost of the products over their life cycles. However, most studies do not examine some factors influencing the adoption of TC systems for manufacturing firms, and consequently exclude service firms from their surveys and analysis. Furthermore, they do not take into account an uncertain environment in a TC system. This paper tries to overcome these shortcomings in existing researches by considering some of the most important features of real world TC in a novel and practical TC model under an uncertain environment. To fill these research gaps, in this paper, a target costing system is adopted for making production-related decision for a manufacturing firm by considering the obtained values in the product and also the net present value of cash flows. As the definitions and measurements of variables in a target costing involve varying degrees of uncertainty and ambiguity, fuzzy set theory and Monte Carlo method are utilized. This study shows the importance of attributes of TC (namely relative advantage, compatibility, ease of use, result demonstrability, trial-ability) for decision makers to adopt and implement such cost and management accounting innovation. Finally, a numerical example as a case study is investigated to demonstrate the applicability of the proposed model and solution approach. The results indicate that the proposed fuzzy TC can be useful among the manufacturing and service firms.

Keywords: Target costing, Net present value, Fuzzy set.

1. Introduction

'Target costing' was originally introduced in Japan under the name of 'Genkakikaku' or Genka Kikaku (Monden and Hamada 2003) and became popular in the English-language literature. The technique also is known as 'cost planning', 'cost projection systems', 'basic net price', 'manufacturing cost reduction', 'pre-calculation', 'direct cost feasibility study', and design to cost Dekker and Smidt (2003). This technique focuses on long-term cost management efforts, which is why the MA literature refers to it as a SMA technique Dekker and Smidt (2003).

Target costing (TC) is defined as a systematic process of managing product costs during the design stage of a new product, establishing market sales prices and target profit margins, and reducing the overall cost of the products over their life cycles (Yazdifar and Askarany 2012). TC contains two key stages: the determination of the target cost and attainment to it. Recently, TC has been developed to assist the decision making process involved in making a new product. It evaluates the decision of producing a certain product from its sale price, which is established by the market. When the TC is reached, the firm may use either a bottom-up or a top- down method such as value engineering to attain it. In other words, TC is set at the level of the allowable cost of product, i.e., at the difference between the target sales price and the target profit. When the estimated unit cost of the product is less than its allowable, or target cost, the product is produced, because it adds economic value to firm. Thus, two main objectives for a TC system: (1) reducing the cost of new products so that the level of required profit could be guaranteed, simultaneously satisfying the levels of quality, development time and price demanded by the market, and (2) motivating all the employees to achieve the target profit during the development of the new product.

A review of the TC literature reveals that TC is often associated with Japanese firms and Japanese researchers for the Japanese context have mainly performed empirical research (Kato 2010; Tani 1995; Cooper and Yoshikawa 1994), and that most western-based research has concerned the rate of mapping usage from TC in different countries (Ax et al. 2008). Surveys on the adoption of TC in Japan report a much higher rate of adoption than by Western firms.1 For example, Lorino (1995) stated that over 80% of large companies in the assembly industries had already applied TC in Japan. In the US, Ernst & Young and The Institute of Management Accountants (2003) found that 26% of IMA member firms had adopted TC. Likewise, Chenhall and Langfield-Smith (1998) reported that of 78 large Australian manufacturing firms, 38% had employed TC. Israelsen et al. (1996) found that 50% of Danish firms had adopted TC. In another study, Dekker and Smidt (2003) reported an even higher adoption rate from a study of Dutch firms listed on the Amsterdam Stock Exchange, with 59.4% of firms using TC. Wijewardena and De Zoysa (1999) found that in their sample of 209 Japanese manufacturing firms that of the 11 studied MA practices, TC was perceived as the most important practice used. The authors also found that for the 225 Australian manufacturing firms they surveyed, TC ranked only tenth in importance among the 11 MA practices. From a survey in NZ, the UK and the USA, Guilding et al. (2000) reported that the adoption rate of TC was moderate. Moreover, Tani et al. (1994) reported that in 1991, 60.6% of their sample of 180 listed Japanese manufacturing firms used some form of TC.

To summarize, then, for those companies that have implemented TC, the stages of implementation are examined at four levels. The four levels, noted below, include two key processes: the determination of the target cost (level 1) and its attainment (levels 2, 3, 4) (Yazdifar and Askarany 2012):

Level 1: Identification of target product cost as the difference between expected price and required profit;

Level 2: Adoption of cost-cutting strategies at the production stage to approach the target;

Level 3: Examination of all cost-reducing strategies at the planning and pre-production stages;

Level 4: Adoption of value engineering to incorporate customer requirements;

1.2. The process of target costing

The uniqueness of Japanese target costing comes into play when strategic product positioning is completed in coordination with the company's general strategy. This is also the point in time when the product-market mix has been determined and information about what product attributes and what related prices consumers desire are collected through a market analysis. Up to that point, the Japanese way is similar to traditional Western cost management. However, there are important differences between these two approaches in the way the market information is gathered and converted into an actual product (Worthy 1991). A more detailed comparison is presented in Fig. 1 (Alinezhad Sarokolaee et al. 2012).

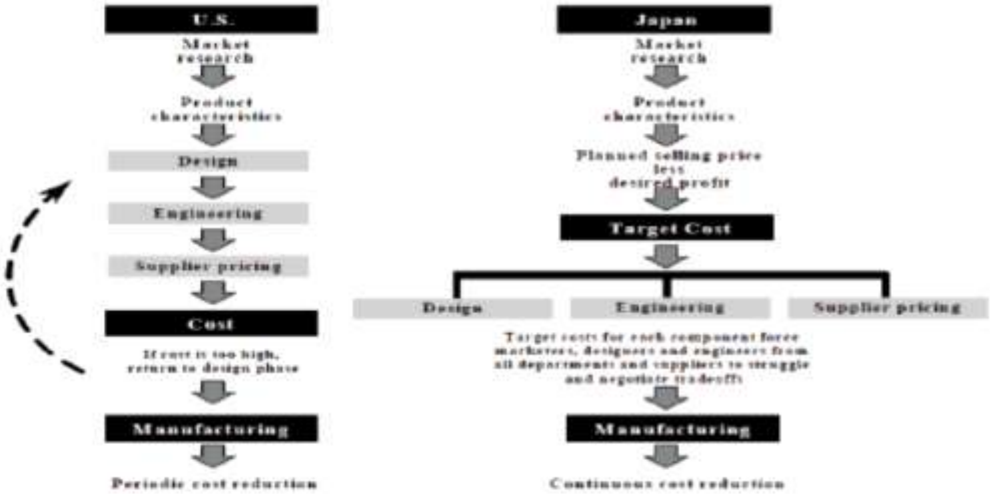

Fig. 1. Western and Japanese Cost Management

From the above discussion, target costing begins with the question: "What should a product's cost be? In theory, this question can be answered by the following well-known equation:

Sales Price – Target Profit = Target Cost

1.3. Motivation and contribution

The traditional TC models systematically underestimate the marginal cost of invested funds and overestimate the marginal cost of cash-related production resources (Kee 2010). Therefore, this model is not suitable to find the target cost because the cost of capital is not considered. To the best authors' knowledge, prior research has not examined the association between the perceived characteristics of an innovation and the actual adoption of TC, by using net present value (NPV) of cash flows. On the other hand, the target costing process involves an inherent subjectivity due to the fact that most of the utilized information is imprecise and ambiguous. While a variety of works on TC have been performed in a deterministic condition, to the best of authors' knowledge, a TC system under uncertain environment not yet been investigated despite its importance. The review of the works on the HLP models presented by (Yazdifar and Askarany 2012) confirms these gaps. This paper tries to overcome these shortcomings in existing researches by considering some of the most important features of real world TC in a mathematical model.

This paper presents a novel and practical TC model under an uncertain environment. As the definitions and measurements of variables in a target costing model involve varying degrees of uncertainty and ambiguity, fuzzy set theory can help managers to improve their product design, costs, and targets. Hence, target cost is calculated based on NPV in a fuzzy environment. In this paper, TC is examined for making production-related decision by considering net present value (NPV) of cash flows. Target cost is calculated based on NPV. The product is produced if it earns a positive NPV and its estimated unit cost is less than target cost.

This study is motivated by the need of considering net present value in a TC system under an uncertain environment. In short, the highlights of the differences of this research with the mentioned studies are as follow:

- Developing a TC model for a manufacturing firm;
- Considering net present value (NPV) of cash flows obtained in the TC model;
- Proposing fuzzy set theory and Monte Carlo method for the proposed TC model;

The application of this study is to generate additional opportunities and cost effectiveness for companies that utilize the target costing system in such an uncertain environment. The remainder of the paper is organized as follows. Section 2 contains the fuzzy target costing. In order to demonstrate the application of the proposed model, computational results are investigated in Section 3. Finally, conclusion is provided in Section 4.

2. Fuzzy target costing

To describe the proposed fuzzy TC and the mathematical model appropriately, this section contains the following notations:

I , initial investment;
$\tilde{P}=(P_a,P_b,P_c)$, fuzzy sale price of the product;
$\tilde{C}=(C_a,C_b,C_c)$, fuzzy estimated cost of the product;
Q , the quantity of the product produced;
t , tax rate;
$\tilde{r}=(r_a,r_b,r_c)$, fuzzy cost of capital;
N , product's economic life;
$P\tilde{V}_{N,r}=(PV_{N,r,a},PV_{N,r,b},PV_{N,r,c})$, fuzzy present value of an annuity for N periods and cost of capital of $\tilde{r}$;
$NP\tilde{V}=(NPV_a,NPV_b,NPV_c)$, fuzzy net present value;

It should be noted that the sale price, estimated cost, quantity of the product produced, tax rate and cost of capital are constant over a product's economic life. The reason to utilize the triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation. As a result, $P\tilde{V}_{N,r}$ is calculates using Eq. (1).

$$PV_{N,r,a}=1-(1+r_c)^{-N}/r_c,\quad PV_{N,r,b}=1-(1+r_b)^{-N}/r_b,\quad PV_{N,r,c}=1-(1+r_a)^{-N}/r_a, \tag{1}$$

Now, $NP\tilde{V}$ is calculates using (2) and (3).

$$\begin{aligned} NPV_a &= (P_a-C_c)Q(1-t)PV_{N,r,a}-I+I(PV_{N,r,a}/N),\\ NPV_b &= (P_b-C_b)Q(1-t)PV_{N,r,b}-I+I(PV_{N,r,b}/N),\\ NPV_c &= (P_c-C_a)Q(1-t)PV_{N,r,c}-I+I(PV_{N,r,c}/N), \end{aligned} \tag{2}$$

Subject to:

$$NPV_a,NPV_b,NPV_c\geq 0. \tag{3}$$

The first terms in (2) measures the present value of the product's operating income after tax while the second and third terms is equal to the difference between the values of the initial investment and the present value of the depreciation expense taken over a product's life where straight-line depreciation is used. Equation (3) represents the constraint where the product must meet for it to be produced. Substituting the right-hand side of (2) into the left-hand side of (3), fuzzy target cost $\tilde{C}^T = (C_a^T, C_b^T, C_c^T)$ is calculates using (4) as follows:

$$Q(1-t)P\tilde{V}_{N,r}\tilde{C}^T = \tilde{P}Q(1-t)P\tilde{V}_{N,r} - I + I(P\tilde{V}_{N,r} / N), \tag{4}$$

Notice that Eq. (4) is a fuzzy linear equation and therefore it is necessary to find the $\tilde{C}^T$. Here, a major problem in solving fuzzy equations is that the some basic operations that we used to solve crisp equations do not hold for fuzzy equations (Buckley and Jowers 2008). Therefore, the classical method, represented as Monte Carlo, is utilized to solve it. This procedure employs α-cuts and interval arithmetic. Consider the fuzzy linear equation in (5) as follows:

$$\bar{A}\bar{X} + \bar{B} = \bar{C}, \tag{5}$$

Where $\bar{A}$, $\bar{B}$ and $\bar{C}$ will be triangular fuzzy numbers and $\bar{X}$, if it exists, will be a triangular shaped fuzzy number. Solution $\bar{X}_c$ when $[X_1(\alpha), X_2(\alpha)]$ define the α-cuts of a fuzzy number is presented in (6) and (7), (Buckley and Jowers 2008):

$$X_1(\alpha) = C_1(\alpha) - B_1(\alpha) / A_1(\alpha), \tag{6}$$
$$X_2(\alpha) = C_2(\alpha) - B_2(\alpha) / A_2(\alpha), \tag{7}$$

Now, in order to specify a fuzzy number using the $X_1(\alpha)$ and $X_2(\alpha)$, we need the following relations:

1) $X_1(\alpha)$ monotonically increasing, $0 \le \alpha \le 1$;
2) $X_2(\alpha)$ monotonically decreasing, $0 \le \alpha \le 1$;
3) $X_1(\alpha) \le X_2(\alpha)$.

Let us to consider $\tilde{C}^T[\alpha] = [C_1^T(\alpha), C_2^T(\alpha)]$ $\tilde{P}[\alpha] = [P_1(\alpha), P_2(\alpha)]$ and $P\tilde{V}_{N,r}[\alpha] = [PV_{N,r,1}(\alpha), PV_{N,r,2}(\alpha)]$ where $0 \le \alpha \le 1$. Hence, $\tilde{C}^T[\alpha]$ is obtained using (8) and (9) as follows:

$$C_1^T(\alpha) = P_1(\alpha)Q(1-t)PV_{N,r,1}(\alpha) - I + I(PV_{N,r,1}(\alpha) / N) / Q(1-t)PV_{N,r,1}(\alpha), \tag{8}$$

$$C_2^T(\alpha) = P_2(\alpha)Q(1-t)PV_{N,r,2}(\alpha) - I + I(PV_{N,r,2}(\alpha) / N) / Q(1-t)PV_{N,r,2}(\alpha), \tag{9}$$

It should be noted that the extension principle and interval arithmetic methods are two other procedures to solve this problem. Now, it is necessary to obtain the α-cuts of $\tilde{C}$ and then compare it to the $\tilde{C}^T$. However, If $\tilde{C}[\alpha] < \tilde{C}^T[\alpha]$, then the product can be produced.

3. Computational results

In order to assess the applicability of the proposed model, a numerical example with one product is designed. The required information are listed in Table 1, where the economic life cycle is 5 year.

Table 1: Data for numerical example.

Information	Value
Initial investment	\$10,000
Sale price	(\$100, \$120, \$140)
Quantity produced (unit)	10
Tax rate	20%
Cost of capital	(8%, 9%, 10%)
Economic life	5 year

From the above Table and using the Eq. (2), then, $P\tilde{V}_{N,r}$ is calculated as (3.79, 3.889, 3.992). As a result, according to Eq. (8) and (9), the target cost $\tilde{C}^T[\alpha]$ with α -cut $[C_1^T(\alpha), C_2^T(\alpha)]$, is shown in Fig. 2.

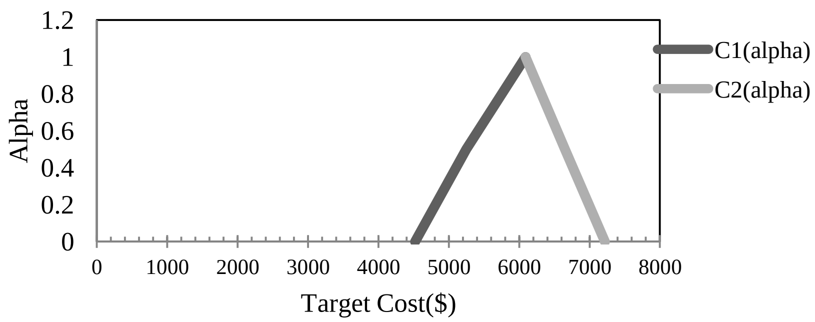

Fig. 2. Target cost with α -cut.

From Fig. 2, it can be seen that $C_1^T(\alpha)$ is monotonically increasing (its derivative is positive), and $C_2^T(\alpha)$ is monotonically decreasing (derivative is negative) and $C_1^T(\alpha) < C_2^T(\alpha)$. Therefore, the solution $\tilde{C}^T[\alpha]$ exists and it can be compared with estimated cost of product. As a result, this product is allowed to produce and sale in market.

4. Conclusion

In this paper, target costing was examined for making production-related decision and was calculated based on fuzzy net present value. As the definitions and measurements of variables in a target costing involve varying degrees of uncertainty and ambiguity, fuzzy set theory and Monte Carlo method were utilized. This study showed that the importance of attributes of TC (namely relative advantage, compatibility, ease of use, result demonstrability, trial-ability) for decision makers to adopt and implement such cost and management accounting innovation. Finally, a numerical example as a case study was investigated to demonstrate the applicability of the proposed model and solution approach. A numerical example demonstrated how this model leads to obtain the target cost in a fuzzy environment considering the positive NPV. The computational results indicated that the proposed fuzzy TC can be useful among the manufacturing and service firms.

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