Novel Fuzzy Regression Approach For Managing Target Cash Balance In Construction Firms

Ken Yeh[1], Cheng-Wu Chen[3], Jine-Lih Shen[1], Shu-Hao Lin[1], Chun-Chieh Chien[2]

[1]Assistant Professor, Department of Civil Engineering, De-Lin Institute of Technology

[2] Lecturer, Department of Civil Engineering, De-Lin Institute of Technology

3 Department of Logistics Management, Shu-Te University

Abstract

This study presented the cash portion of working capital management (WCM) by using the concept of target cash balance and developed a practical model for construction firms in Taiwan for rationalizing the amount of cash and current assets which should be possessed in any point of time. The model developed by Miller and Orr is introduced here for understanding the issues involved. Because the S-curve has unique merits to represent the relationship between project duration and complete progress in practical usage of construction management, based on the technique of Takagi-Sugeno (T-S) fuzzy model, the fuzzy S-curve regression is hereby constructed in this paper.

Key words: T-S fuzzy model, working capital management.

模糊迴歸於營造業承包商現金管理研究

葉根 [1]、陳震武 [3]、沈勁利 [1]、林樹豪 [1]、簡俊傑 [2]

[1]德霖技術學院土木系 助理教授，[2]德霖技術學院土木系 講師

[3]樹德科技大學運籌管理系 助理教授

摘 要

應用 Takagi-Sugeno 模糊理論建立大型專案之 S-curve 迴歸模型，得出一六階多項式 S 曲線模型，繼而應用現金週期概念，推估分析專案履約執行時之現金流量圖形，以瞭解其執行過程中之短期財務需求，增進對現金管理問題的瞭解，再經由修訂 Miller-Orr 現金管理模型，發展出一套彈性雙限目標現金餘額模型，作為業界實務應用及後續研究之參考。這樣的理論模型可幫助瞭解公共建設專案投標期與履約施工期間之短期財務需求，並發展一套容易理解、能被靈活應用的專案現金管理與控制模型，提供營造業承包商實務應用於專案現金管理與控制之參考，以提升其營運資金管理效能(尤其是現金管理部份)，從而控管資金成本以增加營運利益。

關鍵詞: T-S 模糊模式, 資金管理

1 Introduction

General contractors play a prominent role in the construction industry, causing the supply chain to respond to a variety of construction needs submitted by the demand chain. Along the demand chain, public owners, private property developers, banking institutions, and all shareholders of those business entities are directly or indirectly involved in the demand chain. As generally known, a supply market is overwhelmed by a large number of construction companies with relatively comparable backgrounds and capabilities. In this situation, nearly every player involved in the demand chain must evaluate the background of the general contractor(s) before entering into the contract stage.

One of the principle criteria for evaluating a general contractor is the liquidity of his firm. A healthy liquidity greatly improves the firm's solvency and is generally a sign of energetic operating capability. Basically, a firm's liquidity can be fully reflected by his working capital management which covers both short term assets and debts. As carrying too much cash would bear the firm unnecessary financial costs and too little risks of bankruptcy, this study attempts to investigate the range of suitable cash balance for ongoing operations, including maintenance of healthy liquidity, achieving planned profits and meeting all project goals, in a construction firm. As a common assumption, the traditional tendering framework and settings, i.e. separation of design and construction, are considered in the context.

2 Background

Working capital management (WCM) is the emphasis of short-term financial strategy of firms. It encompasses all investment and management endeavors of current assets and current debts. Upon a balance sheet, four main items under the current assets category are (1) cash and cash equivalents, (2) marketable securities, (3) accounts receivable, and (4) inventory. Three major items found as current debts are (1) accounts payable, (2) expenses payable - including accrued wages and taxes--and (3) notes payable. The balance between the scale of current assets and that of debts underpins a firm's liquidity, profitability and solvency and, therefore, is often seemed as an art. An interesting comparison is that typical manufacturing firms channel 40% of their assets in the current form, yet the construction industry's average is in the range of over 70% (Halpin and Woodhead 1998).

There are two vital aspects in working capital management. A firm must first decide on the target level of all forms of its current assets. It then should contemplate upon the sources of financing with respect to each form of current assets. As borrowing incurs operating costs and method of borrowing as well as the associated costs and the likely borrow sums varies, each construction firm is faced with a delicate balance between borrowing too much or too little, if or when it is capable of borrowing. The former would reduce profitability and the latter undermine solvency. Notably, there is more likelihood for a construction firm to borrow less than it needs than otherwise. Chances are the firm can never have enough sources for loans.

As a general rule the firm may possess the following strengths when it has abundant cash (for more details, see Kim and Srinivasan 1988):

1. It can meet unexpected shortage of cash, as transferring current assets into cash is the most convenient;
2. The firm usually is in a price negotiation advantage when it always transacts with cash;
3. As a direct result of the above, the firm is usually regarded high on credit and this in turn enhance its borrowing capability, in terms of a reduced interest rate or an extended loan;
4. As distributing cash dividends to share holders is possible, this practice may attract more source of equity; and
5. With good preparation of current assets, the firm can be set in motion for business opportunities, i.e. winning new bids or joint-venturing with partners, with a short lead time.

In retrospect, the down side of residing too many current assets in-house includes the following:

1. Costs of borrowed capital certainly diminish profitability;
2. As current assets are valuable resource for profits, redundancy is very wasteful; and
3. As a result of the above, the lenders, mostly banks, are alienated to the firm, and this will hamper its borrowing capability.

Being large-scaled, of long duration, high costing, and complex-technical, the large public construction exists many uncertain factors. Because of these factors, to perform this kind of project is difficult, especially for the dispatch of working capital. There is thus a need for engineers to have an appropriate analytical model of project management. Project management is regarded here as the systematic usage of management and construction expertise through the planning, design, and construction processes for the purpose of controlling the time, progress, and quality of design and construction. S-curves are helpful to project management in reporting current status and predicting the progress of project (for more details, see Halpin and Woodhead 1998). Hence, they are widely used in industry and management for control of project (see Miskawi 1989; Romie Tribble 1999; Rudolf 2000, for example).

To solve the problems arising from complex systems may become very inefficient or even impossible if using the traditional mathematical tools that are not constructed for dealing with high dimensionality models. In some cases, we even cannot obtain exact numerical data for the information of systems because of the influence of various uncertain factors. Consequently, the traditional least square regression may not be applicable when dealing with curve fitting problems. In recent two decades, some interesting approaches containing the regression model by fuzzy theory have been attracting increasingly attention, as proposed in the literature (Peter 1994; Tanaka et al. 1989; Xu 1991; Xu 1997; Yang 2002). Furthermore, some approaches concerning management and forecasting of cash flow have been discussed (see Hwee and Tiong 2002; Navon 1996, for example). Although much research has been devoted to fuzzy S-curve regression and working capital management, little information is available on applying project control model via fuzzy regression model to the problem of cash management of construction firms. Aside from this issue, the purpose of this study was to develop a fuzzy regression model via Takagi-Sugeno (T-S) fuzzy model.

This study is discussed as follows. First, the balance between superfluous or shortage of working capital, Miller-Orr model and classic S-curve theory are recalled. Then, based on fuzzy set theory and fuzzy inference engine as well as center of gravity defuzzification, the T-S type fuzzy S-curve is obtained for curve fitting problems. Finally, a numerical example with simulations is given to demonstrate the methodology, and the conclusions are drawn.

3 Methodology

As illustrated previously, the goal of working capital management aims at reducing a firm's current assets to the level as marginally needed as possible. There are two logical steps involved, including identification of working capital and determination of target cash balance, discussed below.

In a construction firm, the needs for working capital may be motivated by transaction concerns, precautionary concerns and speculative concerns. Each of the motive categories is briefly described below.

1. Transaction motive

This is the most common cause for a firm to hold current assets, mostly cash. To a construction firm, the main category of transactions are (1) for outflow of cash, subcontractors, material vendors, equipment leases and direct-hire workers and (2) for inflow of cash, mainly construction clients or their representatives. Salary for internal employees however may not be regarded as this motive.

2. Precautionary motive

As cash outflows and inflows may vary as planned, a firm has to prepare for itself a handful sum of current assets for unexpected shortage of debt payments. By definition, this category is for precaution of short-term insolvency.

3. Speculative motive

A firm may encounter opportunities of price negotiation in procurement of service or material. A lucrative price discount may be offered, if the firm is able to transact with the opposite by cash or the equivalent. For this reason or the like, the firm may be willing to accept the cost of borrowing in hope of high speculative return.

Once the need for working capital is identified, a firm is underway of figuring out its most appropriate level of cash balance or the target cash balance. Any diversion to the target level bears the firm a penalty. When a firm holds superfluous current assets, its penalty is the excess interest payments. On the contrary, if the firm is in need of cash for debt payments, its penalty is the cost of trading notes with cash. Further, if the firm has drained out all current assets, the additional penalty is the opportunity cost for arranging the borrowing in a short time. Obviously, it exists a balance between the two extremes, as depicted in Fig. 1.

This study seeks to understand this balance in a construction firm by incorporating the popular Miller-Orr Model illustrated in Fig. 2 (for more detail, see Juang 1994; Ross et al. 1995). This model argues that the irregular pattern of cash needs along various times can be best handled by the idea of dual control limits. In other words, a firm can use its operating characteristics and credit conditions as a basis for constructing a lower cash balance limit. Similarly, the firm can construct an upper cash balance limit and the target cash balance by using its transaction costs, variance of cash flow, and opportunity cost of holding cash. After identifying the upper/lower limits, it is convenient for the firm to discern timing for investing cash in marketable securities or trading notes for cash. In short, the Miller-Orr model reduces the difficulty of working capital management into finding the target cash balance and the associated limits. The model states that

$$C^* = L + (3/4 * F * \sigma^2 / R)^{1/3} \quad (1)$$

where

$$U = 3 * C^* - 2 * L \quad (2)$$

L: Lower cash balance limit
F: Transaction costs of trading valuable notes for cash or arranging short-term loans
σ^2: Variance of cash flow
R: Opportunity costs, equivalent to interest rate of loans or security notes

Applying Miller-Orr Model in Construction The cash flow of a firm is dependent upon its operating cycle, which begins at procurement of service or material and ends at sales and inflow of revenues. More relevant to the firm, however, is often the cash cycle, which strictly relates to all cash outflows for procurement and the inflows of sales. Although logically connected, in practice, the two cycles may be quite different from each other. For a construction firm, the danger of insolvency often occurs when there is a long delay or considerable gap between a cash outflow and the expected inflow. Markedly, it is impossible to know a firm's cash cycle directly based on its published financial statements. The amount of details involved is enormous. Rather, it is more useful to first peek into a firm's operating cycle and then, by subtracting the accounts payable period, to measure the cash cycle, as depicted in Fig. 3.

Classic S-Curve Theory An S-shaped curve is often used to reflect the phenomena in biology and social economy. It means that the trend of growth gets slow first and finally saturation rapidly. In other words, the typical S-shaped curve is generally a build-up period first, then a relatively steady load period, with a final tail-off period. The characteristic that the build-up and tail-off periods vary from slow to steep depends on the type of project, for example the typical shape of construction activity within a project is a quick build-up period, a steady load period and a slow tail-off period. The relationship between budgets and time limit for a project can be represented via S-curve fitting. A typical S-curve figure is shown in Fig. 4. The x-axis and y-axis denote project duration and complete progress, respectively.

Miskawi (1989) proposed an S-curve equation which can be used in a variety of applications related to project control. The S-curve model is of the following form:

$$P = \frac{3^T}{2}\sin\left[\frac{\pi(1-T)}{2}\right]\sin(\pi T)\log\left(\frac{T+(1.5-T_p)}{T_p+T}\right) - 2T^3 + 3T^2 \qquad (3)$$

where P denotes percentage completion of a project or an activity; T denotes time at any point of the duration of a project or an activity; T_P is shape factor.

Fig. 5 is plotted with various values of T_P between $T = 0$ and $T = 100\%$ duration and the envelope of curves for $T_P = 0$ and $T_P = 100\%$ in Eq. (3).

Here we suppose we can exactly get all observed data taking part in the problems, but, actually, we may not know exact values rather some approximation (Xu 1997). For this reason, the traditional fitting method may not be quite suitable and Xu (1991; 1997) hence proposed an S-shaped curve regression model for fitting data that exist fuzziness or uncertainty. However, the S-curve fitting model by data of large-scale engineering must be different with that of small-scale engineering. In order to let an S-curve model be generally used in capital management for construction firms, Takagi-Sugeno (T-S) fuzzy model is utilized to develop a practical S-curve model. That is to say, the fuzzy regression curve, obtained for project control of large-scale or small-scale engineering, is smoothly connected by the T-S fuzzy model in the following.

Fuzzy S-curve via T-S Fuzzy Model The T-S fuzzy model was developed primarily from the pioneering work of Takagi and Sugeno (1985), to represent the nonlinear relation of multiple input and output data, according to the format of fuzzy reasoning. Namely, the resulting overall fuzzy regression model, nonlinear in general, is achieved by fuzzy blending of each individual input-output realization (for more detail, please see Wang et al. 1996).

Before constructing fuzzy regression model, we are used to choosing the following polynomial equation when k order curve fitting is adopted:

$$y = a_k x^k\,, \qquad (4)$$

by choosing the order k we can represent nonlinear relations. Parameters are determined so that the distance (or error) between an observed data point and its corresponding point on the polynomial will be minimal.

In this paper, we distribute the data clusters of cost into some overlapping regions to represent the outlays of engineering constructions such as shown by the membership functions of fuzzy sets C^1, C^2 … C^i. Therefore, the ith rule of fuzzy inference is described by a set of fuzzy IF-THEN rules in the following form:

Rule 1: IF x is C^1 THEN $y_1 = a_{1k} x_1^k$

Rule 2: IF x is C^2 THEN $y_2 = a_{2k} x_2^k$

⋮

Rule i: IF x is C^i THEN $y_i = a_{ik} x_i^k$ (5)

where in this case x, input, represents the cost and y_i (i = 1, 2), output, stand for progress of work. $i = 1, 2, \cdots, r$; in which r is the number of IF-THEN rules and x is the premise variable. Using the center of gravity defuzzification, product inference, and single fuzzifier, the final output is inferred as follows:

$$y = \frac{\sum_{i=1}^{r} w_i \ y_i}{\sum_{i=1}^{r} w_i} = \sum_{i=1}^{r} h_i \ y_i \tag{6}$$

It is assumed that $w_i \geq 0, \quad i = 1, 2, \cdots, r; \ \sum_{i=1}^{r} w_i > 0$. Therefore, $h_i \geq 0$ and $\sum_{i=1}^{r} h_i = 1$.

Remark 1: w_i is the degree of membership belonging to either the *low* (i = 1) or *high* (i = 2) fuzzy sets. When x is smaller than C^L, the regression model of rule 1 is solely applied. Contrarily, when x is greater than C^H, only regression model of rule 2 is applied. When x is in between, both equations are employed with the continuously varying degree of weight w_i. For instance, as the value of x falls in higher in the interval of [C^L, C^H], more weight is given to the regression model of rule 1, and less weight to the regression model of rule 2.

Remark 2 (Wang and Chiu 1999): the resultant fuzzy number is the same type as the original fuzzy numbers after the operation of addition, subtraction or multiplication. Namely, If A and B are the fuzzy numbers with the same type of membership function, then A+B, A-B and $K \cdot A$, $K \in R$, are also the same type as A and B.

4　Conclusions

We propose here a fuzzy S-curve regression method for a better understanding of the issues involved. The aim is to develop a practical model for construction firms in Taiwan to rationalize the amount of cash and current assets possessed in certain time of duration. A simplified case is also introduced for demonstrating the concept and steps of applying the conceptual model.

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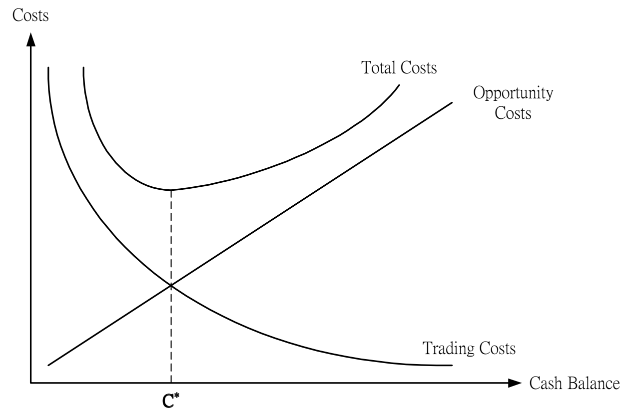

Fig. 1. Balance between superfluous or shortage of working capital

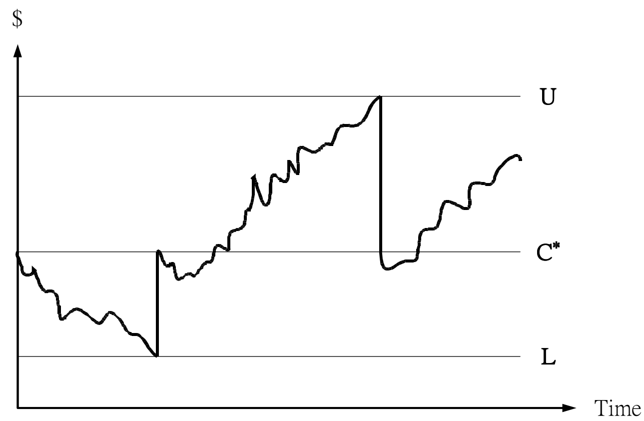

Fig. 2. Dual control of Miller-Orr model.

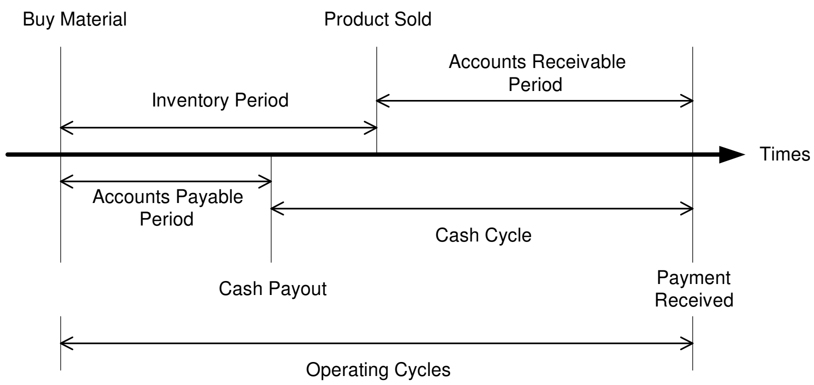

Fig. 3. Relationship between operating cycles and cash cycles

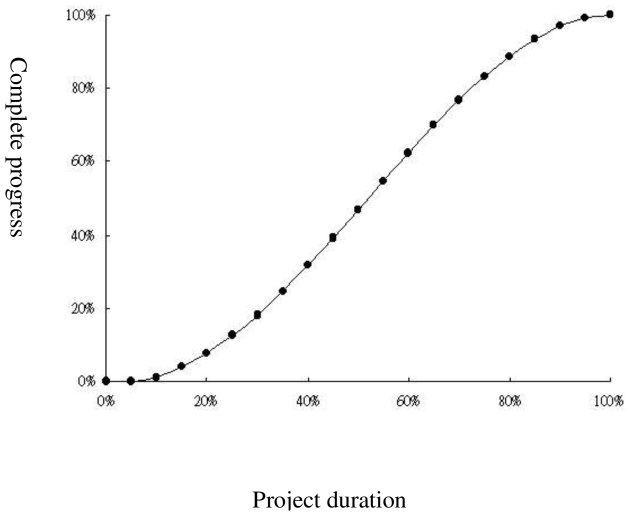

Fig.4. Typical S-curve figure.

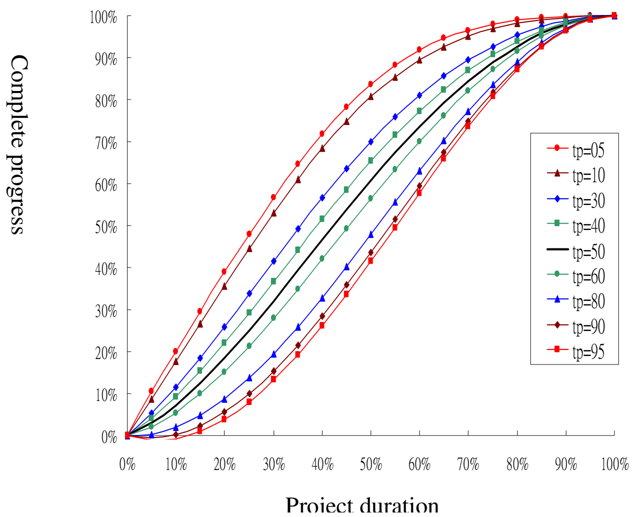

Fig.5. Miskawi S-curve model