Cash flow Forecasting in Construction Industry Using Soft Computing Approach

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Abstract

The cash flow forecasting is normally done by contractors in construction industry at early stages of the project for contractual decisions. The decision making in such situations involve uncertainty about future cash flows and assessment of working capital requirements gains more importance in projects constrained by cash. The traditional approach to assess the working capital requirements is deterministic in and neglects the uncertainty. This paper presents an alternate approach to assessment of working capital requirements for contractor based on fuzzy set theory by considering the uncertainty and ambiguity involved at payment periods. Statistical methods are used to deal with the uncertainty for working capital curves. Membership functions of the fuzzy sets are developed based on these statistical measures. Advantage of fuzzy peak working capital requirements is demonstrated using peak working capital requirements curves. Fuzzy peak working capital requirements curves are compared with deterministic curves and the results are analyzed. Fuzzy weighted average methodology is proposed for the assessment of peak working capital requirements.

Key words: *Peak Working Capital Requirements, uncertainty, statistical measures, fuzzy sets*.

Introduction

The construction industry is large, complex, diverse and covers a wide range of activities. The objective of construction project planning is the completion of a project within in a stipulated schedule, at a pre-estimated cost and with the required standards of quality. Hence, there is a need for financial planning which is an important aspect, due to various uncertainties in the project environment, in the process of attainment of predefined objectives in the construction industry. The assessment of working capital requirements plays a major role in the contractor's financial planning. peak working capital requirements (PWCR) at the end of each assessment period for a contractor in construction industry is the difference of cumulative revenue and cumulative expenditure at any payment period. Assessment of working capital requirements is a continuous process in a cash operating cycle of a construction contractor's project. The contractor must have cash reserves available to initiate construction and to maintain continuity of operations during the time is awaiting payment from the owner (Halpin and Woodhead, 1993). Accurate cash flow forecasting is essential at the tendering stage to all contractors as it provides contractors with information regarding the amount of capital required to perform a contract and the amount of interest that needs to be paid to support overdraft and the evaluation of different strategies (Kaka, 1996). Working capital requirements varies from project to project and contractor to contractor as it depends on the contractual conditions of the project and the credit periods available to contractors from vendors or suppliers. A contractor is at far more risk than his counterpart of any other industry in estimating working capital in construction industry. Therefore the method for determination of PWCR at early stages is critical to the initial decision making process and it is the most important part of the construction contractors' financial management system.

A methodology is proposed in this research to assess PWCR using fuzzy set theory by developing linear membership functions, based on statistical measures at various progress periods of the project duration. This approach takes into account the vagueness and ambiguities inherent in the project contract environment.

Literature Review

Working capital requirements is assessed based on the estimated cash-out-flow (expenditure) and cash-in-flow (revenue) in a construction contract at any stage of project progress. A large number of cash flow forecasting models are available for analysis of cash flow in a construction industry and most of these methods are based on standard S curves.

Kenley et al. (1986) studied the variability of net cash flow profiles by collecting the cash in and cash out data from commercial and industrial projects and comparison of results found that there was a wide degree of variation between the individual project profiles.

Boussabaine et al. (1999) considered cash out flow as uncertain in cash flow analysis. This approach represents the variability in the parameter values. The fuzzy set theory is more appropriate method when there is an ambiguity and fuzziness concerning values of the criteria. In case of complex projects, decision maker may know the interval of the parameter based on the experience but not on the probabilities associated to different values. Ross, (1997) characterizes the fuzziness in a fuzzy set whether the elements in the set are discrete or continuous-in a graphical form for eventual use in Mathematical formalisms of fuzzy set theory.
He presented a methodology for developing membership functions for fuzzy numbers based on statistical measures. Boussamaine and Taha Elhag (1999) mentioned the advantage of statistically based membership functions) is that they are naturally quantitative, that is, there is a reason to believe that the membership function has a relationship to some physical property of the set. They used these criteria which result in simplified but accurate method of defining membership functions for peak working capital requirements. In this paper statistically based fuzzy sets are based on the mean and standard deviation. Civanlar and Trussell, (1986) used more complicated method based on the probability density function of each progress period can be used. There are some conditions for construction of membership functions to make the set have properties consistent with the subjective judgment of a decision–maker and the underlying statistics of the PWCR periods. The elements which are most likely (e.g. at mean) should have high membership values, however, the set should be as selective as possible. Civanlar and Trussell, (1986) stated that these set of conditions might be quantitatively represented

Fuzzy Aggregation Techniques for Assessment of Peak Working Capital Requirements

Linguistic variables provide a means of modeling human tolerance for imprecision by encoding decision relevant information into labels of fuzzy sets (Zadeh, 1993). Fuzzy techniques can be used to model decision processes for which mathematical precision is impossible or impractical. In the case of assessment of peak working capital requirements (PWCR) for a contractor, the shortcomings in traditional techniques for decision making under uncertainty may be addressed through the use of fuzzy systems theory, fuzzy aggregation, and fuzzy logic (Chen and Hang, 1992).

Fuzzy aggregation techniques are demonstrated here to assess peak working capital requirements. These aggregation techniques handle variables for decision making with goals and constraints. Wong et al. (1985) described an algorithm for performing extended algebraic operations on such as those encountered in risk due to earth quakes and decision analysis under fuzzy conditions. Fuzzy aggregation techniques are used here to assess the PWCR at valuation periods. A commonly encountered problem in the assessment of PWCR is the process of development of PWCR alternatives. In a case where the value of the alternatives can be measured through fuzzy membership functions, the membership function can provide a means of evaluating trade off between alternatives of PWCR. The methodology proposed by Dubois and Prade (1984) is used here to evaluate alternatives $A_1, A_2, \ldots, A_n$ of peak working capital requirements in a universe of alternatives $X_1, X_2, \ldots, X_n$ respectively for achieving a given goal. The weighting goals provide appropriate emphasis on each alternative using the following equation:

$$\mu(y) = \sum_{i=1}^{n} W_i \, \mu_i(x) \quad .... (1)$$

The above Eq. (1) requires non-linear programming techniques for evaluation and is difficult to compute. Based on Zadeh's extension principle a Fuzzy weighed average method is proposed and this method is based on the α -cut representation of fuzzy sets and interval analysis. The fuzzy weighted average method provides a discrete approximation of the α cuts of the fuzzy weighted average. PWCR alternatives at different valuation periods are represented by S1, S2,…., Sm and the criteria that is used in the assessment of alternatives are $\alpha_1, \alpha_2, \ldots, \alpha_n$. Then for a chosen alternative S_i the relative merit criterion $\boldsymbol{\alpha j}$ is evaluated by membership function $\mu_{ij}(x)$. The relative importance or the degree of belief in each criterion of selection of an alternative for PWCR is assessed by a weighting coefficient W_j for criterion α_j. Therefore, the PWCR alternative receives the following weighted average membership.

$$\mu_{ij}(x) = \frac{\sum_{i=1}^{m} W_i \, \mu_{ij}(x)}{\sum_{j=1}^{n} W_j} \quad \ldots\ldots \quad (2)$$

The Eq. (2) is used to evaluate fuzzy sets of PWCR at different payment stages of a project. For this three linguistic variables, low, medium, and high, are used to evaluate PWCR. Here, these linguistic variables provide a means of modeling human tolerance for imprecision associated with PWCR by encoding relevant information into labels of fuzzy sets. By evaluating PWCR in terms of linguistic approximation a multi-answer to a crisp (singleton) problem can be provided, allowing decision-makers to test different alternatives of PWCR. Accordingly, decision makers can test different alternatives of PWCR by evaluating PWCR in terms of three linguistic criteria.

Research Methodology

The research methodology for assessment of Peak Working Capital Requirements (PWCR) for contractor in construction industry is as follows.

Step 1: Analyze projects data and compute statistical measures

Step 2: Define linguistic variables based on subjective evaluation of PWCR, that is, low PWCR, high PWCR, medium PWCR etc.,

Step 3: Develop membership functions of fuzzy sets of PWCR in terms of linguistic criteria for every valuation period based on the subjective and objective data of PWCR.

Step 4: Develop weighted membership functions (fuzzy sets) in terms of linguistic criteria such as pessimistic, moderately optimistic, optimistic etc., based on degree of belief associated with the fuzzy variable.

Step 5: Develop fuzzy combinations for assessment of alternative PWCR.

Step 6: Select a required combination for analysis of PWCR.

Step 7:Select α cut on membership function of PWCR and weight (degree of belief) membership function.

Step 8: Use fuzzy weighted average technique for the assessment of PWCR for every valuation period.

Step 9: Compute ∑W*X and ∑W for every valuation period and at every selected α cut.

Where W = degree of belief associated with PWCR, and X = PWCR.

Step 10: Compute aggregated PWCR for every valuation period at every selected α-cut, and

Step 12: Draw defuzzified PWCR curves at desired α-cut and degree of belief.

Illustration with an example

A case study with 25 projects is considered. The cash flow data of 25 projects are analyzed. The statistical parameters are prepared. Three linguistic variables (Low, Medium, and High) for PWCR are chosen with varying degrees of belief (pessimistic, moderately optimistic, and optimistic). Membership functions are developed based on objective data (statistical measures) and subjective data (linguistic variables based on vagueness and ambiguity). As specified in research methodology, linguistic weights were considered for application of fuzzy weighted average technique in the assessment of PWCR. The degree of belief (weights) is in the form of three fuzzy sets, that is, pessimistic, moderately optimistic and optimistic for nine valuation periods.
The linguistic variables are used to represent real variable of PWCR. The PWCR is defined in terms of linguistic variables by decision maker, that is, low PWCR, medium PWCR, and high PWCR. The fuzzy sets of these three linguistic variables are constructed

for every valuation period using statistical measures that is mean and standard deviation. Therefore membership functions for nine progress periods were constructed. The relative importance of each alternative criteria of PWCR is assessed by a weightage coefficient. Weights can be expressed in either numeric (crisp) or linguistic (fuzzy terms). The linguistic coefficients are in terms of linguistic weights and are expressed as degree of belief (pessimistic, moderately optimistic, and optimistic) that the PWCR is low, medium or high. The linguistic weights are used for the purpose of demonstrating the application of fuzzy weighted average technique.

The PWCR for progress period 6 is treated as uncertain by a contractor. There exist several possible combinations of PWCR. Low pessimistic (Lp), moderate optimistic (Mm) and high optimistic (Ho) PWCR combinations are selected to illustrated the computation of the expected PWCR. The following are the corresponding fuzzy sets of the combination at 0, 0.5, 1.0 alpha cuts.

(1) At 0 membership

S (0) = [0.6/-0.281; 0.3/-0.397; 0.7/-0.281]

(2) At 0.5 membership

S(0.5) = [0.8/-0.339; 0.5/-0.339; 0.8/-0.223]

(3) At 1.0 membership

S (1) = [0.4/-0.397; 0.7/-0.281; 0.5/-0.165]

The defuzzification is for valuation period. The decision maker (contractor) can pick up the best alternative based on the experience/intuition. For example, the PWCR with the lowest membership function (belief) in the S1 curve is 0.4/-0.397. In case the decision maker is unable to pick up best alternative for any reason the weighted average approach can be chosen for deciding the PWCR for that valuation period by calculating the centre of gravity of the PWCR for forecasted amounts of different possible combination. Therefore, the PWCR for period 6 at 1.0 α-cut is

$$S1 = \frac{[(0.4x-0.397) + (0.7x-0.281) + (0.5x-0.165)]}{(0.4+0.7+0.5)} = -0.274$$

The PWCR at other levels of alpha cuts in all progress periods can be calculated using the same procedure. The PWCR curves were drawn based on mean values of 25 projects. The PWCR curves for defuzzified values of PWCR at desired α-cuts and all the combinations are drawn for evaluating alternatives.

Discussions

PWCR curves are developed for different possible combinations at various levels of membership values. The defuzzified PWCR curves are a good compromise between low, medium and high PWCR alternatives. From the PWCR curves, it is clear that the shape of the curve largely depends on the uncertainty associated with ambiguity, fuzziness of PWCR and the degree of belief (weight) of decision maker / contractor regarding PWCR. It is clear that the defuzzufied curve at 0.5 membership function is close to moderately optimistic medium curves. This is just a coincidence since the shape of the fuzzy PWCR curve is dependent on PWCR as well as the degree belief in the amount PWCR.

Based on the forecasted defuzzified curves are drawn for PWCR at different levels of α-cuts. It is clearly evident that the peak working capital requirements are affected by the degree of membership at different alpha cuts and also on the degree of belief at various progress periods. The assessment of PWCR is greatly useful and more practical and incorporate the decision makers’ choice based on the experience in determining the alpha cut level and degree of belief which automatically incorporates ambiguity. The decision maker can evaluate the alternatives of PWCR in this approach and can pick the best alternative. The decision variables in this process is treated as independent and it is not possible to satisfy this restriction every time. In case the variables are dependent, then the relationship among the variables can be established and the fuzzy relation can be arrived at and the further research can explore this approach.

Conclusions

Fuzzy theory has been used in this paper to incorporate the ambiguity in peak working capital requirements at different project progress periods. The peak working capital requirements are determined for 25 projects using deterministic approach. The statistical measures are used to develop membership functions of PWCR for all progress periods. The defuzzified curves of PWCR are obtained using fuzzy weighted average technique. The defuzzified curves of PWCR are compared with mean curves of 25 projects. The contractor can determine the PWCR of valuation period at desired α-cut and degree of belief. It is assumed that input variables are independent.

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